NATIVE AND NON-NATIVE PROCESSING OF MORPHOLOGICALLY COMPLEX ENGLISH WORDS: TESTING THE INFLUENCE OF DERIVATIONAL PREFIXES

by

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This paper reports results of a replication and extension of Silva & Clahsen (2008). We used the masked priming paradigm (Forster & Davis, 1984) to measure differences in native and non-native processing of morphologically complex English words. Three groups of participants took part in these experiments: one native English speaker control group, and advanced adult learners of English as a second language (L2) with Spanish or Mandarin Chinese as their first language (L1).

We compared the reaction times provided by lexical decision tasks to determine differences in the processing of five different morphemes. The critical items for our Experiments 1 - 3 were the same variables tested in Silva & Clahsen (2008): the regular past tense inflectional suffix *-ed* and the derivational suffixes *-ness* and *-ity*. We included two experiments to investigate the nature of native and non-native processing of the derivational prefixes, *un-* and *re-*.

Silva & Clahsen (2008) assert that non-native speakers rely on the declarative memory system to process morphologically complex words. They found full priming for native English speakers for both inflectional and derivational suffixes; however, their non-native English speaking participants showed no priming effects for the inflectional suffix *-ed* and partial

priming effects for the derivational suffixes -*ness* and -*ity*. Based on these results, Silva & Clahsen (2008) claim that L2 speakers process inflectional and derivational morphology differently.

The results of this study are inconsistent with Silva & Clahsen (2008) for two of the affixes tested: the inflectional -*ed* and the derivational suffix -*ity*. Our Spanish L2 participants exhibited full priming effects for the inflectional -*ed* suffix, which suggests that the Spanish L2 participants are accessing the procedural memory system when processing English verbs in the simple past. Additionally, the Spanish L2 group in this study provided significantly faster reaction times for the derivational suffix, -*ity* than the Mandarin Chinese L2 group. Since -*ity* is a Latinate suffix and Spanish a Latin language, we believe our Spanish L2 participants are transferring knowledge of L1 morphology when processing morphologically complex words in their L2, which Silva & Clahsen (2008) claim is not a factor in second language processing.

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PREFACE

I would like to thank my committee members for their time and knowledge, my friends both inside and outside of the Linguistic department for their help and encouragement, and the Linguistic department for the grant that helped to deflect the cost of participant payment. Finally, an inordinate amount of thanks goes out to all of the participants that each took a few hours of their time to take part in these experiments.

1.0 INTRODUCTION

Researchers interested in understanding how the mind processes language disagree as to how linguistic forms are stored in the mental lexicon. Debate centers on whether native speakers store words as distinct morphological units or as whole-word representations. Results from off-line experiments (grammatical judgment tasks) that investigate grammatical processing, or on-line studies (event related brain potentials, lexical decision tasks) that examine processing that occur before speakers can apply explicitly learned and/or metalinguistic knowledge, are often open to interpretation.

For first language (L1) word processing, two theoretical models attempt to account for the processing of morphologically-complex words. The principal difference between the two models is in the number of memory systems that native speakers use to form and understand words. The dual-mechanism models of language processing (Clahsen, 1999; Pinker & Ullman, 2002) propose that native speakers use two memory systems, associated with different regions of the mind, to process morphologically complex words. The associative single-mechanism model (Seidenberg & Gonnerman, 2000; McClelland & Patterson, 2002), on the other hand, claims that only one broadly-distributed memory system is available for L1 processing.

According to the associative single-mechanism model, the bare stem of a word, along with all of its complex forms, are each individually stored as whole-word representations in the mental lexicon. Proponents of the single-mechanism model tend to follow the connectionist theory of language acquisition, which proposes that the rate of the phonological, orthographic, and semantic forms of a single word have statistical weights that determine the speed of lexical retrieval. The frequent use of a certain phonological or orthographical structure (i.e., the *-ed* suffix for regular simple past tense) would receive a heavier weight and result in quicker lexical retrieval.

Faster processing of morphologically-complex lexical items is interpreted, by proponents of the dual-mechanism model, to indicate morphological decomposition. A complex word is broken into its different units, which are stored in different memory systems within the brain. The bare stem is retrieved from the mental lexicon, and the morphological units are stored in the mental grammar. When processed, the two parts are accessed and combined in real time. This theory accounts for words that receive regular inflection, for instance, *walk* → *walked*. Words that do not receive regular inflection (e.g., *seek* → *sought*), on the other hand, are expected to have whole word representations in the mental lexicon for all of its parts.

To account for differences in first and second language processing, the two theoretical models attempt to account for differences in native (L1) and non-native (L2) processing. Those who follow the single mechanism model (McClelland & Patterson, 2002; Seidenberg & Gonnerman, 2000) argue that the same system that is used to process one's native language is also used by L2 speakers when processing their second language. The connections are not as strong in the mental representations for the second language, which accounts for slower rates of and the decrease of automaticity for L2 processing.

Proponents of a dual-mechanism model argue that the same system used in L1 processing is also available to non-native speakers: the mental lexicon (declarative memory) for accessing the bare stems of regular words and the mental grammar (procedural memory) for processing regular morphology and irregular linguistic forms. To account for differences in L1-L2 performance, the proponents of the dual-mechanism model argue that slower processing for L2 speakers is due to the fact that non-native speakers do not have the same kind of access to the procedural system as native speakers.

The masked priming paradigm (Forster & Davis, 1984) has been used to establish whether L2 speakers use a dual-mechanism model to process language, in this case: morphologically complex words, in the same way as L1 speakers. This paradigm allows researchers to look at word processing at a level that is "automatic," since the primes are applied before conscious perception of the word. Participant reaction times provide raw data that is used to compare the differences in native and non-native speaker lexical access, with faster reaction times indicating quicker retrieval.

Silva & Clahsen (2008) have recently claimed that L2 learners rely on the declarative system when processing morphologically complex words. They performed four masked priming experiments to test whether a morphologically complex word primed the recognition of a target bare stem form. For L2 learners, their experiments yielded no priming effects for regularly inflected English verbs and partial priming effects for English nouns created by the addition of nominalization suffixes. The results of these experiments suggest that non-native speakers process inflectional morphology differently than derivational morphological forms. The results from Silva & Clahsen (2008) support claims that non-native speakers do not have the same level of access to the procedural memory system as their native speaker counterparts.

Additionally, the conclusions made for L2 language processing in Silva & Clahsen (2008) were consistent for three different groups of L2 learners (German, Chinese, Japanese), and imply that L1 transfer was not a contributing factor in the L2 processing results.

The purpose of this replication study was twofold: to investigate whether the effects of derivational prefixes would show similarities in native and non-native processing and to test the stimuli used in Silva & Clahsen (2008) on participants from an additional group of L2 English learners. Along with the simple past tense morpheme (-*ed*), and the two deadjectival suffixes (-*ness* and -*ity*) tested in Silva & Clahsen (2008), this study measured the priming effects of the derivational prefixes *re*- and *un*-. The additional group of non-native English speakers that we tested consisted of native Spanish speakers who demonstrated an advanced proficiency in English. Mandarin Chinese L2 speakers of English along with a baseline group of native English speakers also performed the five lexical decision tasks for this study.

We will report results from five experiments that each examined the masked priming effects of a morphologically complex prime on the recognition of a corresponding bare-stem representation. The mean reaction times across three priming conditions were compared to gain a greater understanding of how non-native speakers process words in their L2.

1.1 LITERATURE REVIEW

1.1.1 The dual-mechanism and single-mechanism model distinction for L1 processing

At present, there are two opposing theories that attempt to describe how the mind manages to process one's native language (L1). The principal difference in both theories is in the number of memory systems that are used in L1 processing. Dual-mechanism models make a distinction between the processing of regular and irregular linguistic forms, while associative models claim that only one system is available for word processing.

Ullman (2001, 2004)'s dual-mechanism model proposes that the brain uses two memory systems for the processing of one's native language. Under the declarative/procedural model, a dual-mechanism model of language processing, there are two distinct memory systems responsible for different functions of language. These different memory systems can be found in different regions of the human brain.

The "declarative" memory system is responsible for handling the "learning, representation, and use of knowledge about facts ("semantic knowledge") and events ("episodic knowledge")" (Ullman, 2001: p. 106). In terms of language, the declarative memory serves the mental lexicon—the aspects of language that can be memorized and accessed consciously, or explicitly. The arbitrary assignment of sounds to meaning is what creates words in a language. With the help of the declarative memory system, native speakers can process strings of sounds into meaningful units. There is no way to explain why the phonological representation /kæt/ should have the orthographic representation CAT and refer to a feline rather than a blind, flying nocturnal animal, and it is the mental lexicon's responsibility to store this kind of explicit information for words.

According to Ullman (2001, 2004), the declarative memory system is located in the area of temporal lobes, especially the left hemisphere. The "procedural" memory system, on the other hand, is located primarily in the frontal/basal ganglia region of the brain, using especially the left hemisphere for the processing of one's native language.

The procedural memory subserves the declarative memory in the processing of the mental grammar, with the mental grammar referring to the rules that are implicit in one's L1. Aspects of language that are formed by rules are thought to be processed within the procedural memory system. Once the rule has been implicitly learned, there is no arbitrary association of form and meaning and, therefore, no need for any information to be memorized. Native speakers use procedural memory to process aspects of syntax, phonology, and morphology. For instance, the *-ed* suffix used to form the simple past can be added to any regular verb to form this tense (*link* → *linked*) and can also be applied on invented words (*warc* → *warced*) to imply the same meaning in verb tense.

Like the declarative/procedural model, the traditional dual-mechanism models for word processing (Pinker, 1994; Chomsky, 1995) posit two systems for language processing: an associative memory system and an innate grammar system. The traditional dual-mechanism models claim that different areas of the mind are dedicated to handling the functions of the two systems, with the associative memory located in the left posterior region and the grammar on the left frontal cortex. Additionally, the traditional dual-mechanism models assert that the associative memory system is responsible for the learning and processing of words and information that must be learned by rote; the mental grammar is innate and cannot be "learned," like the information that is stored in the associative memory system. Under the traditional dual-mechanism models, irregular forms of words are stored with whole word representations in the associative memory. Words with regular morphological representations, on the other hand, can be processed using the innate grammar system during on-line processing.

Ullman's (2001, 2004) proposal differs from the traditional dual-mechanism models because the procedural memory in this new model refers to the "learning and computation of sequential and hierarchical structures," (Ullman, 2001: p. 107), which are the innate rules in the traditional model. Additionally, the traditional dual-mechanism models specify regions of the brain where the mental lexicon and the mental grammar are processed, but does not allow for any interaction of the two systems.

In contrast with the dual-mechanism models is the single-mechanism model (Seidenberg & Gonnerman, 2000; McClelland & Patterson, 2002) for L1 processing. Instead of two different systems, the single-mechanism model features one memory system that processes language based on "distributed representations" (Seidenberg & Gonnerman, 2000: p. 357). The single-mechanism model is a computational system that makes no distinction between arbitrary or rule-based forms of language. Instead, proponents of the single-mechanism model explain that one system uses different strengths of correlations of various items to process the various aspects of language, including phonology, morphology, and orthography.

The declarative/procedural model proposed by Ullman (2001, 2004) is similar to both the traditional dual-mechanism model and the single-mechanism model in some regards. Most obviously, both the dual-mechanism models represent the mental lexicon and mental grammar as two different systems. Ullman's (2001, 2004) model deviates from the traditional dual-mechanism model in that the declarative/procedural model attempts to explain the interactions of the two systems for the formation of new "rules"—an effort that allows his model to try to attempt explaining non-native language processing. Ullman's (2001, 2004) model is also similar to the single-mechanism model of language processing in that both models use a system to predict "associations—in learning, representation, and processing" (Ullman, 2001: p. 108). While the single-mechanism model does not refer to specific regions in the brain, Ullman's (2001, 2004) model attempts to do so by claiming that the mental grammar is located in the left frontal/basal ganglia region and it subserves the mental lexicon which is found in the temporal lobes.

1.1.2 On-line studies of L1 processing

Researchers use on-line psycholinguistic methods such as reaction times (RTs) in lexical decision tasks or event-related brain potentials (ERPs) in an effort to validate theoretical language processing models (See Clahsen et al., 2010 for review). Data collected using the masked priming paradigm (Forster & Davis, 1984) help us better understand the nature of native language processing. Under this paradigm, a flash of a prime word, which researchers usually manipulate in some way, appears before the target word in a lexical decision task to measure the effect, if any, of the prime word (or non-word) on the lexical access of the target word. Priming effects are measured by comparing the reaction times (RTs) of three conditions: a baseline/identity, an unrelated, and the primed condition.

Regular and irregular inflection has been widely studied using masked priming experiments as a data collection method, in an effort to test the two divergent models of language processing. Researchers have been able to measure differences in the rate of lexical retrieval for regular and irregularly inflected verb forms in a number of languages. Results from these studies that look at English L1 processing of the simple past *-ed* morpheme have yielded consistent results in favor of a dual-processing model of native language processing. Stanners, et al. (1973) was one of the first studies that found an effect for regular simple past inflection (*-ed*) in English that was not present in the processing of irregular forms (e.g., *sang* → *sing*). The results from this study are thought to show the differences in storage for regular and non-regular morphological structures. Regularly inflected morphemes are stored outside of the mental lexicon and irregular past tense English verbs have whole-word representations in the declarative memory system.

The results found in Sonnenstuhl, Eisenbeiss, & Clahsen (1999) provide additional support for the dual-mechanism model. In a cross-modal study that investigated the priming effects of regularly versus irregularly inflected German verb forms on the bare form target, Sonnenstuhl, Eisenbeiss, & Clahsen (1999)'s study yielded significantly slower RTs for the primes with irregularly inflected verb forms than primes with regular inflection. L1 participants in this study logged RTs for regularly inflected verbs that were similar to the baseline condition, which indicates that regularly inflected German verbs can be decomposed into verbal constituents in the procedural memory and are available for on-line processing.

1.1.3 Differences in native and non-native word processing

Non-native processing is typically slower than and also not as automatic as native processing. In order to account for differences in L1 and L2 processing, many factors, including working memory or L1 transfer, can elucidate non-native processing.

The single- and dual-mechanism models also try to account for differences in native and non-native processing. Proponents of the single mechanism model (Seidenberg & Gonnerman, 2000) argue that L2 learners process their second language(s) using the same system as they do their native language. The single-mechanism model attempts to make predictions about learning according to the strength of associated connections upon a certain structure, in terms of phonology, morphology, and syntax. The slower rate of L2 processing is accounted for by the fact that the associative connections are not as strong for the L2 as they are for the native language, which could also be a sign of L1 influence.

Ullman's (2001, 2004) procedural/declarative model, likewise attributes differences in native and non-native processing to disparities in the access to the two memory systems. Ullman (2001, 2004) argues that L1 speakers use both the procedural memory for processing the mental grammar, including morphologically complex word forms, and the declarative memory for processing irregular word forms. Under the declarative/procedural model, however, L2 learners do not have the same access to the procedural system as native speakers. Because the hierarchal system of rules has not been implicitly acquired, non-native speakers are expected to overuse the declarative memory when processing their second language.

Maturational changes, including the increased amount of estrogen in the brain, cause physical changes that inhibit the unconscious application of rules that were explicitly learned by adult L2 learners. Ullman (2001, 2004) argues that grammatical rules can be processed by L2 speakers, but they tend to be consciously applied, which indicates retrieval from the declarative system. However, Ullman (2001) also asserts that “practice with the L2 should increase the language’s relative dependence on procedural memory for grammatical computations” (p. 110), which suggests that length of exposure and overall proficiency could shift L2 dependency from the declarative memory system.

Using ERPs to track differences in non-native morphological processing, Hahne, Mueller, & Clahsen (2006) found evidence to support claims that L2 speakers have access to the dual-mechanism model for inflectional morphology. Their study forced Russian L1-German L2 participants to make a series of off-line judgment tasks to determine whether regular and irregular inflection was occurring. In instances where regular inflectional affixations were violated, the researchers tracked a processing violation in the L2 subjects. Similarly, they found that rule violations occurred when participants judged words with irregular inflectional plural suffixes that were replaced with irregular forms. Although the off-line judgments made by the L2 participants in Hahne, Mueller, & Clahsen (2006) suggest that non-native speakers have access to the same processing system as native speakers, the results of their study, however, do not imply that non-native speakers use the dual-mechanism model in the same manner as L1 speakers. In other words, just because L2 speakers have access to the procedural/declarative system does not mean that they use it. In particular, “L2 learners do not employ early processes of word-internal morphological decomposition” (Hahne, Mueller, & Clahsen, 2006, p. 129) when processing inflected words in their L2. The results from this study indicate that non-native speakers have the potential to process inflectional morpholopy, depending on the morpheme.

A different study that tested German inflectional past participles (Sonnenstuhl, Eisenbeiss, & Clahsen, 1999), provided data that showed L2 participants exhibiting more "native like" processing of the German regular past tense participles. These results, taken together, suggest that the internal structure of the morphological unit used in affixation plays a role in how native and non-native speakers will process the complex word.

1.1.4 Morphological decomposition as a measure for native processing

Masked priming experiments attempt to understand the nature of language processing and use the structure of morphologically complex words as a measurement. These experiments rely on the mind's ability to segment complex words into their different constituent parts, so that *linked*, for instance, separates into a stem (*link*) and affix (*-ed*). According to the dual-mechanism model of language processing, *link* and *-ed* are represented in different memory systems. The stem is stored in the declarative memory and the affix is retrieved from the procedural system. Morphological decomposition is crucial to the design in experiments that use the masked priming paradigm. The presentation of an affixed word before its bare stem is expected to yield retrieval times that are similar to the baseline condition. This is because processing is thought to happen at the earliest stages of word recognition, i.e., before explicit application of rules.

Muente, Say, Clahsen, Schiltz, & Kutas (1999) used ERP evidence to show that morphologically complex words are decomposed into their stems and morphological units. Their study compared the electrophysiological responses of native English speakers reacting to visual word displays of bare verb stems, which were primed by their past tense forms, whether regular (*baked* → *bake*) or irregular (*sought* → *seek*). The results of Muente, et al. (1999)

indicate that morphological decomposition occurs in native speakers, as they found ERP effects for the regularly inflected words but no effects for the irregular forms. This disparity in the processing of regular and irregular verb forms is understood to show that morphologically complex words do not have whole-word representations in the mental lexicon. Rather, Muente, et al. (1999) believe that their results provide evidence in support of dual-mechanism processing models. Since the brain is unable to decompose verbs with irregular inflection (*sought* → *seek*) as well as suppletive forms (*went* → *go*) into morphological units, these forms have to be stored as whole-word representations in the lexical memory. Concurrently, only the stems of regularly affixed words receive representations in the declarative memory. Muente, et al (1999) also reported similar results from experiments in languages other than English demonstrate that morphological decomposition is an indicator of processing.

Rastle, Davis, Marslen-Wilson, & Tyler (2000) also found that morphological decomposition occurs during native word processing. Rastle, et al. (2000) tested the influence of semantic and orthographic information on the processing of morphologically complex words in experiments with three different onset times (43 ms, 72 ms, and 230 ms). Their experiments found priming effects for English derived forms that were due to semantic but not orthographic similarities. This study revealed that complex words, in which the morpheme had no semantic relationship with the stem, provided significant priming effects *only* during the later stages of word recognition. Stronger priming effects were provided when the meaning of the stem was preserved in the complex form. The fact that the storage of the derived word's meaning is tied to the meaning of the stem suggests that morphological processing is occurring during native word processing. Rastle, et al. (2000) found semantic effects for targets primed with the longer onset time of 230 ms (p. 518). Since morphological decomposition is expected to occur in the early stages of word recognition, before implicit knowledge can be accessed, this evidence of decomposition suggests that the mind handles derivational and inflectional morphology similarly. The constituent parts of a derived complex word, then, are stored in different regions of the mind.

1.1.5 Testing morphological decomposition in L1 and L2 speakers

Silva & Clahsen (2008) used masked priming experiments to determine native and non-native priming patterns for both inflectional and derivational suffixes in English. The English L1 participants in this study demonstrated full priming effects for both types of affixes. The non-native speaker participants in Silva & Clahsen (2008)'s study, however, exhibited different patterns of processing, which were dependent on the type of affixation used to form the morphologically complex word. No priming effect was provided by any of the L2 groups tested, for the inflectional affix tested (the regular simple past tense -*ed* marker), while the derivational suffixes, -*ness* and -*ity*, yielded partial priming effects for both German L2 and Mandarin Chinese L2 groups. The results from these studies provide evidence in favor of the declarative/procedural model of language processing.

In terms of non-native word processing, Silva & Clahsen (2008)'s study suggests that L2 speakers have access to the same processing system as native speakers, but only for morphologically complex words that are created through derivational processes. The absence of priming effects for the inflectional morphemes for the L2 participants in Silva & Clahsen (2008) suggests that non-native speakers store the simple past tense forms of verbs as whole-word representations in the mental lexicon. In effect, Silva & Clahsen (2008) claim that non-native speakers exhibited an overreliance on the declarative memory during on-line processing of morphologically complex words.

Neubauer & Clahsen (2009) recently tested L1 and L2 processing of morphologically complex verbs in German using a masked priming design in an effort to measure the priming effects of regular and irregular verbal inflection in German. The subjects tested in Neubauer & Clahsen (2009) were native speakers of Polish, an inflectionally rich language, albeit with verbal morphology that is distributed differently than in German. The critical items used in this experiment did not differ in terms of orthographic, phonological, and semantic overlap between primes and target choices. Therefore, "any priming differences between these two conditions are likely to be morphological in nature" (Neubauer & Clahsen, 2009, p. 419). The German native speakers in Neubauer & Clahsen (2009) exhibited full priming effects for both regular and irregular past participle forms, while the Polish L2 participants showed no reliable signs of priming. The results provided by Neubauer & Clahsen (2009) provide additional support for the claims made in Silva & Clahsen (2008) that non-native speakers store inflected word forms as whole word representations in the mental lexicon and native speakers use morphological decomposition to process affixed words using the procedural memory system.

1.1.5.1 L1 transfer

Some research studies (Chen, Shu, Liu, Zhao, & Li, 2007; Sabourin & Haverkort, 2003) attribute the first language of the participant to helping L2 participants supply results that are more like the native speakers because of typological similarities between the two languages. Silva & Clahsen (2008), however, found no such effect. As the results in Silva & Clahsen

(2008) showed no significant difference between all groups of L2 participants, the researchers have claimed that L1 transfer is not a factor in L2 word processing. Even the native German L2 participants in Silva & Clahsen (2008), whose native language has an inflectional system that more closely resembles the English system than the Japanese and Mandarin Chinese systems, patterned more like the other non-native participants. This lack of L1 transfer could imply that all non-native speakers process words in their L2 in the same way.

1.1.6 The present study

Additional studies that replicate the methods used in Silva & Clahsen (2008) are necessary in order to test the validity of the results found in their study and evaluate the claims made by the researchers. Since studies that investigate the nature of derivational morphological processing are not as abundant in the literature as ones that test the influence of inflectional morphology, we sought to test the difference, if any, in native and non-native processing of morphologically complex English words that contain derivational prefixes. Some differences exist between derivational prefixes and suffixes in English beyond place of affixation. Instead of changing only the case or the grammatical category of the stem, the derivational prefixes tested in this study also alter the meaning of its base form. Suffixes are more likely to cause a shift in stress in morphologically complex words, as is the case with the suffix -*ity*, tested in Silva & Clahsen (2008). McCormick, Rastle, & Davis (2008), though, showed that stem changes that occur before or during affixation do not affect priming results.

We used the three sets of stimuli used in Silva & Clahsen (2008) in addition to the derivational prefix stimuli (see Tables A4 and A5) as the critical items for these experiments to test L2 processing of the following English affixes: simple past -*ed*, nomializing -*ness* and -*ity*, negative prefix *un*-, and *re*-, with the meaning "to do again."

An additional aim of this research study was to test the critical items used in Silva & Clahsen (2008) on additional groups of L1 and L2 speakers to see if the experiments in these studies would yield priming results similar to those found in Silva & Clahsen (2008). We included an additional group of non-native English speakers in this study to determine any potential L1 transfer effects. This study included a group of native Spanish speakers in addition to native Mandarin Chinese speakers of English and a native English speaking control group.

The derivational prefix, -*ity*, as well as the two derivational prefixes that we tested in this study, *un*- and *re*-, have equivalent morphological forms in Spanish (i.e., fatali*dad* – fatality, madur*ez* – maturity; *des*empacar – unpack; and *re*edificar - rebuild). In fact, one of these prefixes, *re*-, uses the same form to indicate the same meaning ("to do again") in both Spanish and English. If the Spanish L2 group show priming effects that differ from the other non-native group tested, an L1 transfer effect may help explain any significance that exists between the L2 groups. Likewise, if *re*- provides results that differ from the priming results provided by the Spanish group in Experiments 1 - 4 in this study, then these results could suggest an L1 influence during processing.

1.1.6.1 Facilitory effects

Rather than indicating morphological decomposition, it is possible that any full priming effect could be caused by the similar forms in both primes and targets. Since form overlaps both orthographically and semantically in both morphologically complex and baseline primes, the priming effects of targets primed by these conditions could be the result of form, rather than morphological priming. Rastle, Davis, and New (2004) found that native English speakers were able to rapidly segment targets that were formed by only an apparent morphological relationship between stem and affixed prime (corn*er* - CORN) in addition to words for my semantically transparent relationship for prime-target pair (clean*er* - CLEAN). These two conditions were compared with reaction time data from a third set of prime-target pairs that had no morphological relationship (broth*el* - BROTH), which exhibited no priming effects. The influence of orthographic overlap in on-line word processing experiments will be considered in the Discussion section of this paper.

1.2 RESEARCH QUESTIONS

The present study is a replication and extension of Silva & Clahsen (2008), a masked priming study that measured the priming effects of the three affixes: the inflectional simple past *-ed* suffix, the deadjectival suffixes *-ness* and *-ity* on three different L2 groups (German, Mandarin Chinese, Japanese). In this study, we also tested the influence of two derivational prefixes: *un-* and *re-* on two different L2 groups (Spanish L2 and Mandarin Chinese L2) to test the influence of derivational prefixes on non-native word processing.

This study was guided by the following research questions:

a) Will both the Spanish and Mandarin L2 groups in this study show no priming effects for inflectional suffixes and partial priming effects for derivational suffixes as in Silva & Clahsen (2008)?

b) Will the English L1 and Mandarin Chinese and Spanish L2 groups in this study show any priming effects for derivational prefixes?

c) Will this study's findings support Silva & Clahsen (2008)'s claim that L1 was not a factor in the difference between native and non-native processing?

d) Because the prefix *re*-, meaning "to do again" is the same in English and Spanish in both form and meaning, will the L2 Spanish group priming effects differ from the L2 Mandarin Chinese group for this derivational prefix?

2.0 METHOD

2.1.1 Participants

Three different groups participated in these experiments with native language (L1) acting as the independent variable. Group 1 consisted of 25 native English speakers (mean age: 21.48, range: 18-29, 7 males), which served as a control group. These participants were recruited from the University of Pittsburgh's undergraduate and graduate student body, primarily from beginner foreign language or linguistic classes. Participants were offered either extra credit points or a $5 gift card for their participation in these studies. Data from one participant was not included in the analyses because the participant spoke language other than English at home since birth.

Groups 2 and 3 consisted of "advanced/proficient" L2 English speakers with Spanish or Mandarin Chinese, respectively, as L1s. These two L2 groups were chosen based on the different morphological structures of the two L1s. Like English, Spanish is a "multimorphemic" (Frost & Grainger, 2000: p. 322) language and contains verbal prefixes similar to the English prefixes tested in these experiments. Furthermore, Spanish and English use the same prefix, *re-*, to indicate the same meaning: "to do again." Unlike English or Spanish, Mandarin Chinese is "monomorphemic" (Frost & Grainger, 2000: p. 322). Although there is a way to express *re-* in Mandarin, there seems to be no equivalent to the English *un-* for verbs.

Participants in Groups 2 and 3 were recruited from the greater metropolitan area of Pittsburgh, the majority of whom are members of the city's academic community—studying or working at either the University of Pittsburgh or Carnegie Mellon University. After initial recruitment of participants via flyers and listserv posts, several participants recruited their peers to participate in these experiments, which resulted in a snowball sampling effect. A summary of group *n*-sizes is shown in Table 4. Group 2 consisted of 24 members (mean age: 33.04, range: 19-61, 7 males) who came to the US from 9 different Spanish-speaking countries. The

Table 1. Native country information for participants in Spanish L2 group

Country	No. of participants
Argentina	4
Colombia	8
Cuba	1
Dominican Republic	1
Guatemala	2
Mexico	2
Peru	2
Puerto Rico	1
Spain	3
Total	24

majority of participants in Spanish L2 group were from Latin American countries, as can be seen in Table 1. There were 26 qualified participants in The Mandarin Chinese L2 group (mean age: 27.23, range: 21-42, 8 males). Table 2 shows the home countries of the participants in The Mandarin Chinese L2 group. The four participants from Taiwan reported that Mandarin Chinese, not Taiwanese, was their native language.

Table 2. Native country information for participants in Mandarin Chinese L2

Country	No. of participants
China	22
Taiwan	4
Total	26

Data from participants who were exposed to English in an ESL setting before the age of 10 were not submitted to analysis. In total, four participants from each L2 group had to be excluded from the analyses because they were exposed to English in a native setting before the age of 10. The mean age for age of onset for the Spanish L2 group was 11.0 (range: 3-18) and the Mandarin Chinese L2 group was 11.46 (range: 9-14). The length of time that the participants in the two L2 groups have lived in the United States varied widely from over 2 decades to just 2 months. All qualified participants reported that they had been exposed to English in a classroom setting. Three participants in the Spanish L2 group reported that they received approximately 3 hours per week of additional instruction from a private tutor in their native countries. No participant indicated a need to use English outside of the classroom before the age of 18, except in the interest of reading books or watching television shows in their original English versions or chatting with friends for extra conversation practice.

All participants performed the five lexical decision tests, except for 2 participants in the Mandarin Chinese L2 group: one participant only took the lexical decision tests for Experiments 2, 3, and 4 and the data from another participant is missing for Experiment 4.

The non-native English speaking participants were administered the Michigan Test of English Language Proficiency (MTELP), Form R, to determine if they qualified as “advanced/proficient” speakers of English for the purpose of these experiments. The MTELP is a paper-based proficiency test that requires test-takers to select from four given choices to answer the 100 questions with regards to grammar, vocabulary, and reading.

Only data from candidates with scores above 80 (out of a maximum score of 100) were included in our analyses. A score of 80 on the MTELP is defined as “very good” (http://ingles.ing.uchile.cl/otros/downloads/CONVERSION%20PUNTAJES.pdf), is estimated to fall within the “Upper Intermediate” range of the Oxford Placement Test (OPT) (http://www.arts.ac.uk/docs/Equivalence_Chart.pdf), and is the score used by many American universities as a baseline for admission. The data from one Mandarin Chinese L2 participant, who scored a 79 on the MTELP, was not submitted to analyses. An additional three Mandarin Chinese L2 participants along with one Spanish L2 participant scored below 80 on the MTELP, and their scores and RTs were not considered in any of the statistical analyses.

Although the Spanish L2 group outperformed The Mandarin Chinese L2 group on the MTELP with an average score of 89.67 (sd: 6.91) for the Spanish L2 group and 86.7 (sd: 4.64) for the Mandarin Chinese L2 group, comparison of the mean scores for the two L2 groups through an independent mean t-test showed that there was no significant difference between

Spanish L2 and Mandarin Chinese L2 groups for this proficiency measure ($F(48) = 6.39$, $p = 0.082$). The average scores for both of this study's L2 groups fall within the "advanced" range of the OPT; however, the Spanish L2 group showed a trend effect for the MTELP scores which indicates that the Spanish L2 group is slightly more proficient in English than the Mandarin Chinese L2 participants.

Table 3. Estimations of English proficiency or placement test scores equivalent to the MTELP

Name of test			
MTELP	TOEFL Computer-based	IELTS	Oxford Placement Test (OPT)
100	300	9.0	Proficient
		↕	
	271	8.5	
		↕	
	270	8.0	Advanced Strong
95	267	↕	
	240	7.5	
90	237	↕	
	225	7.0	
85	213	↕	Advanced
	210	6.5	
80	200	↕	Upper Intermediate
	196	6.0	
		↕	
	181	5.5	Strong Intermediate

Note: The highlighted sections show how the MTELP scores, in intervals of 5 compare to the TOEFL Computer-based, IELTS, and OPT tests.

A paper-based cloze test was given as an additional proficiency measure to the L2 candidates at the end of the testing section. A final version of the cloze test was determined after three versions were piloted on a total of 24 English L1 and one Spanish L1 volunteers. Each participant took part in only one version of the cloze test, and the final version was determined after 7 L1 English volunteers averaged 1.14 errors out of a potential of 40. The errors were either grammatical or contextual in nature.

An "appropriate word" instead of an "exact word" method of scoring (Brown, 2004: p. 202) was used to evaluate each participant's score on this proficiency measure. We chose the former method over the latter based on the performance of the native speaker judges. Since the native speaker judges were unable to consistently reproduce the source article (the 7 L1 English volunteers who took the final version of the test would have averaged 3.43 errors out of 40), we did not think it was reasonable to expect the non-native participants to do so.

Table 4. Summary of participant data

L1	*n*-size	Age	Age of onset	MTELP score	Cloze score
English	25	21.48 (sd: 3.6)			
Spanish	24	33.04 (sd: 9.11)	11.0 (sd: 4.31)	89.67 (sd: 6.91)	31.08 (sd: 6.36)
Mandarin Chinese	26	27.23 (sd: 5.32)	11.46 (sd: 1.50)	86.73 (sd: 4.64)	28.12 (sd: 4.91)

Under the "appropriate word" method of scoring, answers that differed from the word in the original version of the article, but were grammatically and contextually accurate, were not considered erroneous. Participants' answers that demonstrated appropriate grammar usage and correct morphology yet differed from the original version of the article were still thought to show command of the English language. Thus, the "appropriate word" method was used to score the cloze test.

In the written instructions to the cloze test, participants were directed to write one word within the blank to complete the article. If no answer or more than one word was written in the blank, the answer for that instance was logged as incorrect. The Spanish L2 group outperformed The Mandarin Chinese L2 group on the cloze task. Out of a potential 40, The Spanish L2 group averaged a 31.08 (sd: 6.36) and The Mandarin Chinese L2 group averaged 28.12 (sd: 4.91). A independent mean t-test showed no significant difference for the cloze test scores for these two L2 groups ($F(46) = 1.45$, $p = 0.076$). Although the Spanish L2 group was not significantly more proficient than the Mandarin Chinese L2 group, the t-test showed a trend effect, which suggests that the Spanish L2 participants were slightly more advanced speakers of English than the Mandarin Chinese L2 participants.

Upon completion of the experiments, the L2 participants received a payment of $20 cash. All participants had normal or corrected-to-normal vision and were told that these experiment would look at how quickly non-native speakers recognized English words. They were, therefore, unaware that the primes were in position during the lexical decision tasks.

2.1.2 Materials

This study's was based on Silva & Clahsen (2008). Table 6 shows a summary of the experiments and affixes tested in Silva & Clahsen (2008), including prime exposure times and the group information for the native and non-native English speaking participants tested.

E-Prime software (Psychology Software Tools, Inc., 2002), Version 1.1, was used to run the lexical decision tests in Experiments 1-5. Each experiment contained three combinations of prime-target pairs. By comparing the reaction times (RTs) between the different prime-target pairs (Condition), the effect of priming could be measured. See Table 7 for a list of the three conditions and five affixes under investigation in this study.

Table 5. Definitions for the different priming types

Type of priming	Definition
Full priming	RTs in Condition 1 & 2 are similar to each other and different than RTs in Condition 3
Partial priming	RTs for Condition 1 are faster than Condition 2 and faster in Condition 2 than in Condition 3
Repetition priming	RTs are shorter for Condition 1 than in Condition 3
No priming	RTs in Conditions 2 & 3 are not different

Reaction times were recorded by measuring the length of time between the exposure of the target word (or non-word) on the computer screen and the amount of time required for participants to perform the lexical decision. By comparing the different RTs among the three conditions, the extent of priming can be determined. As set forth in Silva & Clahsen (2008) and shown in Table 5, "full priming" occurs when the RTs for the Identity and Test conditions (Conditions 1 and 2, respectively) are similar and both shorter than the Unrelated condition

(Condition 3). When "full priming" occurs, the effect of the Test condition is an indicator that the morphological processing is occurring. The morphologically-complex prime is opening up the lexical entry in the same way as the Identity condition and, therefore, allowing the participant to access to the target at a faster rate. This faster rate of lexical access manifests itself in quicker

Table 6. Summary of experiments in Silva & Clahsen (2008)

Experiment 1, 3, 4:	tested 3 groups (English L1, German L2, Chinese L2) used prime exposure time of 60 ms
Experiment 1 – tested inflectional past tense suffix *–ed*	
Experiment 3 – tested derivational deadjectival suffix *–ness*	
Experiment 4 – tested derivational deadjectival suffix *–ity*	
Experiment 2:	tested 2 groups (English L1, Japanese L2) used prime exposure time of 30 ms
Experiment 2 – tested inflectional past tense suffix *–ed*	

RTs. "Partial priming," then, is when participants take more time to respond to the Test condition than the Identity condition and longer for the Unrelated condition than the Test condition. "Repetition priming" occurs when the Identity and Unrelated conditions are significantly different, and "no priming" occurs when there is no difference between the mean reaction times in the Test and Unrelated conditions.

Each of the five experiments contained an equal amount of prime-target types for the three prime-target pair conditions. Every experiment contained a total of 21 prime-target pairs — 7 in each Condition. To ensure that each prime-target pair was tested in all 3 conditions and that each participant would only see each target word one time, the 21 prime-target pairs were distributed among three different versions of tests. This means that the 21 target words were tested under the Test condition every 3 participants. The versions were alternated within the different L1 groups. In total, Version 1 was used 25 times; Version 2, 26 times; and Version 3, 24 times.

Both prime and target words were checked for frequency in the CELEX database (Baayen, Piepenbrock & van Rijn, 1993). This study used the same primes as those used in Silva & Clahsen (2008) for Experiments 1, 2, and 3. Tables A1, A2, and A3 list the prime-target stimuli that will be used in the replication experiments. The primes and their CELEX frequencies listed in Tables A4 and A5 were used to test reaction times for derivational prefixes in Experiments 4 and 5. In Silva & Clahsen (2008) "primes were matched as closely as possible for frequency and length" (p. 249). The Test primes for Experiments 4 and 5 have lower frequencies than the bare stem forms, which could contribute to any potential lack of priming.

Each lexical decision task contained a total of 324 words. In addition to the 21 critical items, each experiment consisted of 303 "filler" words and non-words. Table 8 shows the breakdown of the different combinations of the filler stimuli. In order to "prevent participants from developing strategies based on the distribution of particular word forms" (Silva & Clahsen, 2008: p. 49), additional primes were created in which we manipulated either the semantic and orthographic characteristics of the target word. Each lexical decision test also included a total of 162 non-words as targets in order to counterbalance the positive and negative answers of the lexical decisions. Each filler stimulus was used in only one experiment so that participants would only see the filler words/non-words one time.

Stimuli for the Derived, Inflected, Nucleus and Onset word/non-word combinations were chosen and/or modified from the General Service List (GSL) (http://www.nottingham.ac.uk /~alzsh3/acvocab/wordlists.htm). Although the GSL is not a list of the most commonly used English words, the stimuli used in this study were selected from the first 2,000 words on the list. We worked under the assumption that the filler stimuli were common in the English language and that these advanced participants would have had some familiarity with the greater majority of these words.

When preparing the filler data, we used affixed forms as primes and bare stem forms as targets for the Derived combinations (see Table 8). The Inflected word/word prime-target combinations consisted of verbs with simple past tense inflection as primes and bare-form verbs as targets. Stimuli were manipulated for both the Nucleus and Onset prime-target pairs. We changed the nucleus in the first syllable of the word for the former set of pairs and manipulated the first onset of the word for combinations in the latter set. We consulted the *New Oxford American Dictionary* to confirm that all of the non-words created for the purposes of these experiments did not exist in the English language. In addition to the non-words created for the Nucleus and Onset combinations, the remaining non-words used in these tests were taken from the online *Oxford English Dictionary* (http://www.oed.com/). As with the non-words created for the Nucleus and Onset prime-target pairs, we researched all of the non-words words taken from the *OED*'s list of nonce words using the *New Oxford American Dictionary* in an effort to confirm that they never existed in the English language.

The 9 different pairs of prime-target pairs were modeled after Silva & Clahsen (1998)'s experiments in order to "prevent participants from developing strategies based on the distribution of particular word forms” (p. 249). The stimuli were presented in a randomized order, selected by the E-Prime software package.

2.1.3 Procedure

We collected reaction time data for this study by using the masked priming paradigm (Forster & Davis, 1984). The masked priming technique was developed so that “any observed priming effects cannot be a result of any conscious appreciation of the relationship between the prime and the target stimulus” (Forster 2003).

A series of ten hash marks (font: Verdana, size: 18) appeared on a 21” monitor for 500ms before the target word (or non-word) appeared. The font was in black and presented on a white background. The number of hash marks corresponds to the length, in characters, of the longest stimuli used in these experiments. While participants were focusing their gaze on the hash marks, the prime word, in all lowercase letters, "to minimize the visual overlap between primes and targets" (Silva & Clahsen, 1998: p. 250), appeared for 60 ms. Then, finally, the target word, presented in all uppercase letters, replaced the hash marks on the monitor screen and forced the software to begin calculating the reaction time.

Table 7. Description of the prime-target pairs tested in Experiments 1 - 5

Experiment	Condition	Prime target type	Example Prime	Example Target
1	1	Identity	wrap	WRAP
	2	Test		
		Inflectional Morpheme -*ed*	wrapped	WRAP
	3	Unrelated	greet	WRAP
2	1	Identity	dumb	DUMB
	2	Test		
		Derivational Morpheme -*ness*	dumbness	DUMB
	3	Unrelated	short	DUMB
3	1	Identity	valid	VALID
	2	Test		
		Derivational Morpheme -*ity*	validity	VALID
	3	Unrelated	rough	VALID
4	1	Identity	hook	HOOK
	2	Test		
		Derivational Morpheme *un*-	unhook	HOOK
	3	Unrelated	search	HOOK
5	1	Identity	build	BUILD
	2	Test		
		Derivational Morpheme *re*-	rebuild	BUILD
	3	Unrelated	hope	BUILD

We chose 60 ms for the prime exposure time because the participants should not have been able to see the prime and then consciously process it within this length of time. Although Lavric, Clapp and Rastle (2007) found that some semantic information is reported to be available at 60 ms, we chose to use this length of prime exposure time because of the report in Forster (1999) that 60 ms is the approximate amount of time required in order for the brain to open a lexical entry (p. 10). Since "priming is seen as a savings effect" (Forster, 1999: p. 10), the amount of exposure time should be equal to the priming effect. If the data in Forster (1999) is accurate and the length of time to open a lexical entry is approximately 60 ms, then the priming effect should be effective with a 60 ms exposure time. Additionally, the 60 ms exposure time was chosen as it was the length of time used in Silva & Clahsen (2008)'s Experiments 1, 3, and 4—the three experiments that are the basis for this study's Experiments 1 - 3.

In effect, the subliminal flash of the prime word, however brief, allows lexical access to occur at a quicker rate. For all of these experiments, we were working under the assumption that masked priming leads to quicker lexical access, and, therefore, results in faster RTs.

After exposure to the stimuli, participants were forced to make a lexical decision by pressing a *Yes* or a *No* key. The *Yes* and *No* keys corresponded to the *V* and *N* keys on a standard American keyboard. A tiny green piece of paper labeled, "Yes" and a red piece labeled "No" were attached to the keyboard to further indicate where these keys were. Participants were instructed to keep one finger on the *Yes* and one on the *No* key, at all times throughout the experiment so reactions times were not compromised.

Table 8. Explanation of filler stimuli used in lexical decision tests

Type	Prime/target combination	Quantity used in experiment	Example
Derived			
	Affixed word/Word	35	ADVISER/ADVISE
Inflected			
	Affixed word/Word	35	AIMED/AIM
Nucleus			
	Non-word/Word	27	WURE/WIRE
	Nucleus – Word/Non-word	31	SQUID/SQUOD
Onset			
	Onset – Non-word/Word	27	NEGINE/ENGINE
	Onset – Word/Non-word	31	INVENT/NIVENT
Unrelated	Unrelated – Non-word/Word	17	SPERT/CROWN
	Unrelated – Word/Non-word	19	CHEAP/STRIBE
Non-word	Non-word/Non-word	81	MOSSIFY/MOSSIFY

Although all of the lexical decision experiments performed in this study were self-paced, each took approximately 8-10 minutes to complete, with all five experiments lasting less than one hour. After completion of each experiment, participants were offered the opportunity to take a break before they began the next one. All testing took place in the same office, lit appropriately according to the time of day that testing took place. Each participant received instructions to adjust themselves so that they were as comfortable as possible and to turn off their cellular phones.

Participants were given written and oral instructions of the design of the experiments. As the participants were aware that their reaction times were under investigation, they were instructed to make their decisions as quickly and as accurately as possible. One participant said that he was able to see the prime words, so this participant’s data was not included in the statistical analyses. Three participants from The Mandarin Chinese L2 group reported difficulty reading the targets because the letters were all uppercase.

Total testing time for participants in Groups 2 and 3 ranged from 1.5 hours to 2.5 hours. All lexical decision tests and proficiency measures were self-paced.

2.1.3.1 Statistical Measures

The distribution for the three groups was positively skewed so we transformed the group means in an effort to normalize the distribution for these groups. Both the error data and the reaction times for the 21 critical items for each experiment were analyzed using a mixed-design omnibus analysis of variance (ANOVA) with two variables: Group (L1, Spanish L2, Mandarin Chinese L2) and Condition (Identity, Test, Unrelated). Since the L2 groups had more variability, however, the error data for each experiment underwent the Friedman non-parametric test to reliably determine goodness of fit. If any significance was shown, we ran a Wilcoxon Signed Ranks test to establish which Group and/or Condition caused the significant effect for the error data.

The transformed log data were used in the reaction time statistical analysis. We used a repeated-measure analysis of variance (ANOVA) to determine any priming effects for the RT data with Group and Condition as variables and Group held constant. We performed post-hoc paired *t*-tests to see if the ANOVAs yielded significant p values, with significance at or below 0.05. The post-hoc tests compared the three prime-target conditions for each of the three groups to determine if the experiment yielded full, partial, repetition, or no priming effects for each group.

For the by-items analysis, we submitted the error data to a Kruskal-Wallis test to determine which Group provided more erroneous answers for a given experiment or which items in a particular Condition received more incorrect responses. We then submitted the log reaction time data to an additional repeated-measure ANOVA, in which both Group and Condition were treated as repeated factors, to determine if the items in any experiment were problematic for our participants.

To test if L1 is a factor contributing to differences within these two groups, the RT results for the Spanish L2 and Mandarin Chinese L2 groups were submitted to an additional repeated-measure ANOVA test to determine if there is interaction of Group and Condition. If the results from this additional ANOVA test yield a significant p value, then L1 must be considered as an influence on L2 processing. These data would contrast with claims made in Silva & Clahsen (2008).

If the two L2 groups in this study yield no priming effects for the processing of inflectional morphemes and partial priming effects for the processing of derivational morphemes, then this study can add support to Silva & Clahsen (2008)'s claim that L2 learners rely on declarative memory when processing morphologically complex English words.

3.0 DATA ANALYSIS

3.1 EXPERIMENT 1 – INFLECTIONAL SUFFIX *-ED*

This experiment tested for priming effects of inflectional affixes on the recognition of the base form of the verb. The inflection affix in question was the *-ed* suffix used to form the simple past tense for regular verbs. The target words tested for Experiment 1 were the same 21 verbs in Silva & Clahsen (2008)'s Experiments 1 and 2. (See A.1.)

The non-parametric test for the error data only revealed an effect of Condition for the Spanish L2 group, with significance between Conditions 1 and 2 for the Spanish L1 group. Table 9 shows the percentage error data for each group in each condition in this experiment. As is seen in Table 9, the Spanish L2 participants gave erroneous answers for 7.1% of the targets primed by the Unrelated condition. Compared with the other two groups, this high percentage rate probably contributed to the significant interaction of Group and Condition. For the by-items analysis of the error data, we found no effect of Condition for Experiment 1.

Erroneous responses accounted for 4% of the total critical items in this study's Experiment 1, and the RTs of these items were excluded from the reaction time analyses.

Table 9. Mean reaction times (in milliseconds) and percent error for Experiment 1

	Condition	Mean	Standard Deviation	Percent Error
English L1				
(n = 25)	Identity	561	(113)	4.0%
	Test	538	(96)	1.7%
	Unrelated	600	(100)	4.0%
Spanish L2				
(n = 24)	Identity	692	(279)	1.8%
	Test	671	(253)	3.0%
	Unrelated	738	(211)	7.1%
Mandarin Chinese L2				
(n = 25)	Identity	645	(191)	3.4%
	Test	720	(295)	4.6%
	Unrelated	765	(237)	2.9%

The ANOVA for the reaction time data revealed an effect of Group ($F_1(2, 71) = 4.27$, $p = 0.018$; $F_2(2, 180) = 43.3$, $p < 0.001$) and Condition ($F_1(2, 142) = 14.34$, $p < 0.001$; $F_2(2, 180) = 21.24$, $p < 0.001$), but no significant interaction of Group and Condition ($F_1(4, 142) = 1.65$, $p = .166$; $F_2(4, 180) = 1.72$, $p = 0.147$).

The mean RT for the English L1 group in this study's Experiment 1 was actually slower in the Identity condition than in the Test condition, but post-hoc tests revealed that the difference between these two conditions was not significant. For the native English speakers in this study, the RTs were the slowest for the Unrelated condition.

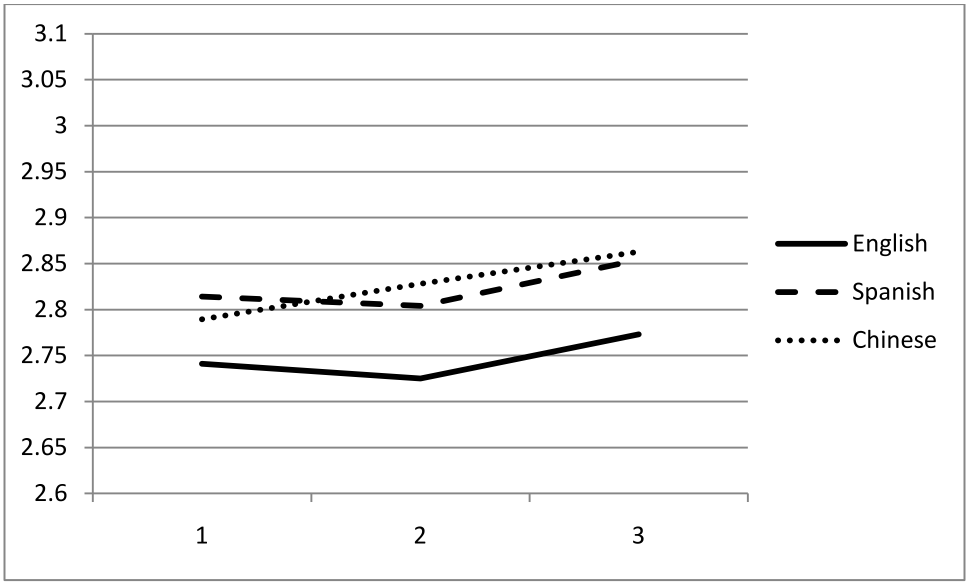

Figure 1. Plot of mean RTs across Conditions for Groups in Experiment 1

Although the native speakers did not yield a significant difference between the Identity and Unrelated conditions, the post-hoc tests showed that Group 1 produced similar reaction times for Conditions 1 and 3. The native speakers in this study did not demonstrate a repetition priming effect for the items in Experiment 1; however, there was indication that the Test condition produced a priming effect because the post-hoc test showed a significant difference between the Test and Unrelated conditions for the English L1 group. The fact that the English L1 group logged slower mean reaction times under the Identity condition might be contributing to the lack of repetition priming, which, in turn factored into the lack of priming for the native English speakers. The slower RTs under Condition 1 for the native speakers could be attributed to their performance on the items that were presented in the Identity condition.

Table 10. Results from the post-hoc tests for Experiment 1

	English L1	Spanish L2	Mandarin Chinese L2
Test – Identity	t = 0.89	t = 0.54	t = -2.15*
Test – Unrelated	t = -2.68*	t = -2.74*	t = -1.96
Identity – Unrelated	t = -1.79	t = -2.19*	t = -4.11*

The Spanish L2 data for this Experiment 1 patterns like the English L1 data in that the RTs were fastest in the Test condition, followed by Identity, and then slowest in the Unrelated condition. Post-hoc tests (see Table 10) revealed that there was no difference in RTs in the Test and Identity conditions and also that both the Test and Identity conditions were significantly different than the Unrelated condition. The RT data for the native Spanish speakers suggest a repetition priming effect as well as a full priming effect of the inflectional simple past tense *-ed* morpheme.

For the Mandarin Chinese L2 group, the RT times for the Test condition were faster than the Unrelated one; furthermore, the Mandarin Chinese L2 speakers showed a repetition priming effect, with the Identity condition being significantly longer than the Unrelated condition.

An additional ANOVA revealed that there was no difference between the two L2 groups for the interaction of Group and Condition, implying there was no L1 effect for the decomposition of inflectional morphology.

3.2 EXPERIMENT 2 – DERIVATIONAL SUFFIX -*NESS*

This experiment tested the possible priming effects of the deadjectival suffix *–ness* on the bare stem of the target items. The 21 critical items used in this experiment were the same targets used in Silva & Clahsen (2008)'s Experiment 3. (See A.2.)

Table 11. Mean reaction times (in milliseconds) and percent error for Experiment 2

	Condition	Mean	Standard Deviation	Percent Error
English L1				
(n = 25)	Identity	555	(105)	2.9%
	Test	554	(76)	2.3%
	Unrelated	624	(143)	5.1%
Spanish L2				
(n = 24)	Identity	699	(209)	7.1%
	Test	682	(192)	6.0%
	Unrelated	687	(213)	5.4%
Mandarin Chinese L2				
(n = 26)	Identity	768	(297)	7.7%
	Test	823	(324)	8.2%
	Unrelated	833	(223)	5.0%

The non-parametric test for the error data for these items showed no effect of Condition for any of the three tested groups. Similarly, the by-items analysis yielded no significant effect of Condition. Table 11 reports the mean percent errors for each condition. Erroneous answers were found for 6% of the total responses, and these responses were excluded for the RT ANOVA analyses.

The by-subject analysis of the reaction time ANOVA showed a significant effect of Group ($F_1(2, 72) = 9.83$, $p < 0.001$; $F_2(2, 180) = 55.0$, $p < 0.001$) and Condition ($F_1(2, 144) = 3.92$, $p = 0.022$; $F_2(2, 180) = 5.52$, $p = 0.005$) but no significant interaction of Group and Condition ($F_1(4, 142) = 1.74$, $p = 0.144$; $F_2(4, 180) = 1.5$, $p = 0.20$). The large amount of variability within the Spanish L2 and the Mandarin Chinese L2 groups might have contributed to the lack of significance for the interaction of Group and Condition.

The post-hoc tests for this experiment also showed a full priming effect for the native speaker participants, as is shown in Table 12. The mean RTs for Group 1 were almost identical across all conditions in this study's Experiment 2.

According to the post-hoc tests, no priming effects were recorded for the Spanish L2 group in this study, not even a repetition priming effect. The RTs for The Spanish L2 group in this study were only a few milliseconds apart across all conditions, and the longest mean RT was actually found for the targets primed by the Identity condition. The Mandarin Chinese L2 group in this study, though, showed a repetition priming effect, as participant RTs yielded faster results for Identity primes than Unrelated ones. The additional ANOVA that we performed for the two L2 groups showed that there was no significant difference between the two groups in this study. Like the Spanish L2 group, The Mandarin Chinese L2 group also showed no priming effect for the derivational affix -*ness*.

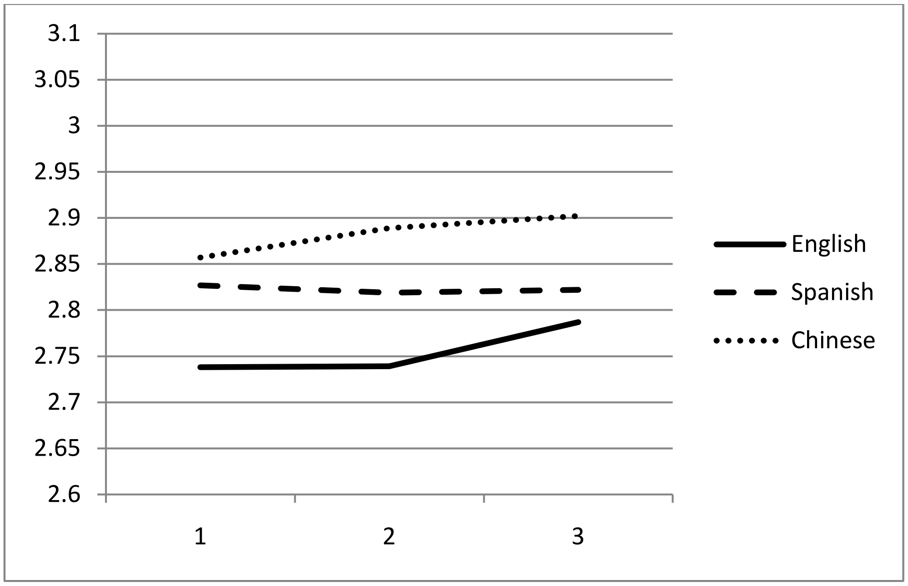

Figure 2. Plot of mean RTs across Conditions for Groups in Experiment 2

The results of the post-hoc tests, which are shown in Table 12, suggest that significant effect of Group found for this Experiment was caused by the full priming effect found for the English L1 participants. The effect of Condition could be caused by the slower responses in the Unrelated condition that were made by all of the groups in this study.

Table 12. Results from the post-hoc tests for Experiment 2

	English L1	Spanish L2	Mandarin Chinese L2
Test – Identity	t = -0.5	t = 0.44	t = -1.86
Test – Unrelated	t = -2.63*	t = -0.16	t = -0.76
Identity – Unrelated	t = -2.68*	t = 0.27	t = -2.61*

3.3 EXPERIMENT 3 – DERIVATIONAL SUFFIX *-ITY*

This experiment is a replication of Silva & Clahsen (2008)'s Experiment 4, with the prime-target pairs used for this experiment modeled to measure the influence of the deadjectival suffix, *-ity*. (See A.3).

The error data was submitted to a non-parametric test to check for goodness of fit, which showed an effect of Condition for Group 1. The mean percentage error rates in Table 13 show an error rate for the Unrelated condition that is significantly higher than the error rate for the Test condition. All participants provided a larger percentage of errors for the Unrelated condition in this experiment; however, the English L1 group provided the only significant difference. The by-items analysis also revealed an effect of Condition for the native English speakers, who made significantly more errors for items in the Unrelated condition (9.8%) than the Identity (4.3%) and Test (3.4%) conditions.

Table 13 shows that participants from all of the three Groups made the most errors in the Unrelated condition. Experiment 3 yielded the highest error rate of all of the experiments in this study, with a total error rate of 10%. The Mandarin Chinese L2 group, in particular, provided the most incorrect responses to items in this experiment than in all of the other experiments in this study. This high rate of errors could be attributed to the lower frequency in some of the primes and targets used in this experiment. The targets, *arid*, *docile*, and *sterile*, seemed to cause some difficulty for participants, regardless of Group; and the Mandarin Chinese L2 participants, in particular, provided more erroneous answers for *profane* and *solemn* than either the English L1 and Spanish L2 groups. The erroneous answers from Experiment 3 were not included in the reaction time data analysis.

Table 13. Mean reaction times (in milliseconds) and percent error for Experiment 3

	Condition	Mean	Standard Deviation	Percent Error
English L1				
(n = 25)	Identity	612	(340)	4.6%
	Test	590	(99)	3.4%
	Unrelated	656	(108)	9.7%
Spanish L2				
(n = 24)	Identity	636	(142)	5.4%
	Test	661	(205)	6.0%
	Unrelated	717	(194)	8.6%
Mandarin Chinese L2				
(n = 26)	Identity	908	(304)	15.4%
	Test	1116	(428)	15.4%
	Unrelated	1027	(324)	19.2%

The reaction time ANOVA for this study's Experiment 3 revealed significance for Group ($F_1(2, 72) = 20.89$, $p < .001$; $F_2(2, 180) = 109.0$, $p < 0.001$) and Condition ($F_1(2,144) = 6.87$, $p = 0.001$; $F_2(2, 180) = 8.6$, $p < 0.001$) but no effect for the interaction of Group and Condition ($F_1(4, 144) = 1.69$, $p = 0.156$; $F_2(4, 180) = 0.832$, $p = 0.51$). Compared with the English L1 and Spanish L2 groups, the Mandarin Chinese L2 participants provided much slower reaction times across all of the different prime conditions. Figure 3 shows the plots of the mean RT times for the three groups in this study across all conditions. The RTs for the Spanish L2 group pattern similarly to those for the English L1 group, but the Spanish L2 group provided the fastest RTs in the Identity condition, while the English L1 group had its fastest responses for targets primed by the Test condition. Both the English L1 and Spanish L2 groups have the slowest RTs under the Unrelated condition. In contrast, the Mandarin Chinese L2 group is slowest in Condition 2, which could have lead to the significant effect of Condition.

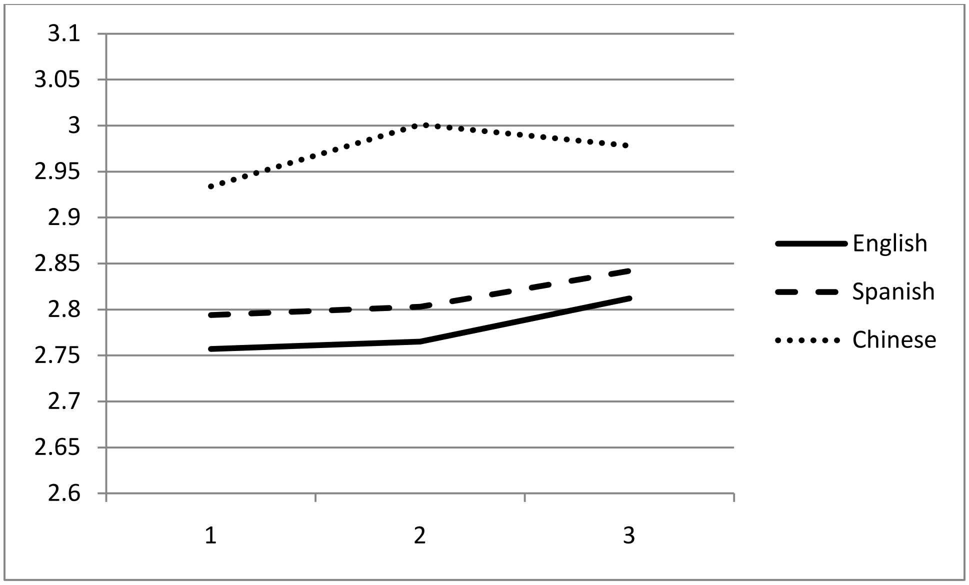

Figure 3. Plot of mean RTs across Conditions for Groups in Experiment 3

As can be seen in Table 13, the Test and the Identity conditions for both the English L1 and Spanish L1 groups are similar, though only the native English L1 group showed a repetition priming effect. While the English L1 respondents gave the fastest responses for the Test condition, the Spanish L2 group provided the shortest RTs in the Identity primed condition, followed by Test, then Unrelated. The post-hoc test results for The Spanish L2 group in this experiment showed no significant difference in RTs between any of the Conditions. According to the definitions of the priming effects outlined in Table 5, the fact that there is no difference between the Test and Unrelated conditions, means that the Spanish L2 group demonstrated no priming effect for the morphological representation of -*ity*. The Mandarin Chinese L2 group also showed no priming effect for the derivational suffix in this experiment, as is suggested in the significant difference between the Test and Identity conditions.

Table 14. Results from the post-hoc tests for Experiment 3

	English L1	Spanish L2	Mandarin Chinese L2
Test – Identity	t = -0.34	t = -0.37	t = 2.89*
Test – Unrelated	t = -1.99	t = -1.61	t = 0.99
Identity – Unrelated	t = -2.32*	t = -1.99	t = -1.90

The additional ANOVA for the two L2 groups, however, did show a significant difference for the two L2 groups. This significance suggests a possible L1 effect for this test item, the *-ity* suffix, which is of Latin origin. Although the by-subject data did not show a repetition priming effect or any difference between either the Test or the Identity conditions with the Unrelated condition, the significant difference between the L2 groups is indicative of a something happening in the item data that is contributing to the lack of priming for the Spanish L2 group.

Since a similar suffix is found in the native language of participants in the Spanish L2 group (usually represented by the suffix *-idad* in words such as, *fatalidad* – fatality or *tocicidad* – toxicity), and the addition of this suffix to the base-form forces a shift in stress parallel to the *-ity* suffix in English, the difference between the two L2 groups for Experiment 3 could suggest a L1 influence for the Spanish speakers for the derivational suffix *-ity*. If this is true, then the claim in Silva & Clahsen (2008) that L1 transfer is not a factor in non-native word processing should be reevaluated.

3.4 EXPERIMENT 4 – DERIVATIONAL PREFIX *UN-*

This experiment tested verbs that can also feature the prefix *un-* as the prime to bare stem targets. Table 24 contains the 21 critical items tested in this experiment, along with the CELEX frequencies of both the bare verb and the prefixed form of the verb.

Table 15. Mean reaction times (in milliseconds) and percent error for Experiment 4

	Condition	Mean	Standard Deviation	Percent Error
English L1				
(n = 25)	Identity	586	(176)	4.6%
	Test	566	(107)	3.4%
	Unrelated	705	(341)	6.9%
Spanish L2				
(n = 24)	Identity	751	(308)	13.1%
	Test	793	(325)	9.5%
	Unrelated	761	(252)	15.5%
Mandarin Chinese L2				
(n = 25)	Identity	780	(350)	5.1%
	Test	806	(258)	10.9%
	Unrelated	757	(180)	11.4%

We submitted the error data for this experiment to a non-parametric test, which yielded no significant effect of Condition for any of the participant Groups for both the by-subject and by-items analyses. Table 15 shows the mean percent errors across Groups and Conditions. The native speakers provided the least errors for all Conditions.

Participants gave erroneous responses to 9% of all critical items in Experiment 4. These erroneous answers were not included in the reaction time analysis.

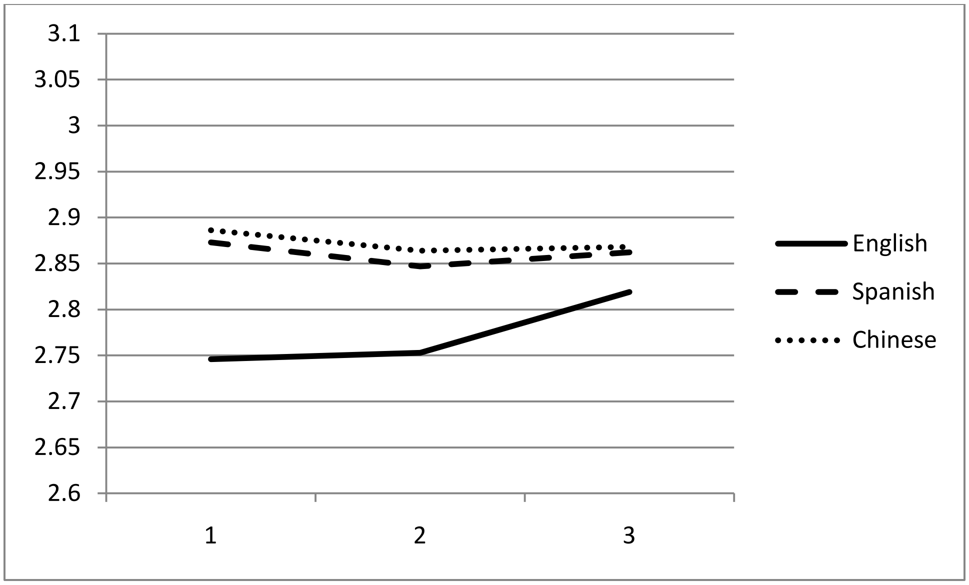

Figure 4. Plot of mean RTs across Conditions for Groups in Experiment 4

The reaction time ANOVA for Experiment 4 revealed an effect of Group ($F_1(2,71) = 5.91$, $p = 0.004$; $F_2(2, 180) = 31.2$, $p < 0.001$) but no significance for Condition ($F_1(2,142) = 2.50$, $p = 0.069$; $F_2(2, 180) = 3.5$, $p = 0.03$). The interaction of Group and Condition, however, was significant ($F_1(4, 142) = 2.74$, $p = 0.031$) for the by-subject analysis, but not for the by-items analysis (F_2 $(4, 180) = 1.5$, $p = 0.21$). The effect of both Group and the interaction of Group and Condition is probably caused by the lower mean RTs for the native speaker control group for this experiment. The Spanish L2 group logged higher mean percentage rates in Experiment 4 than any of the other experiments in this study.

As shown in Table 15, the L1 English group logged faster reaction times in the Test condition than in the Identity or Unrelated conditions. The difference between the Identity and Test conditions, however, was not significantly different for the native English speakers. The post-hoc tests showed that both the Test and Identity conditions were significantly different than the Unrelated condition, which is indicative of a full priming effect. In contrast to the native

English speakers, neither of the L2 groups provided a repetition priming effect or any other priming effect for *un*-. The Spanish L2 group had faster RTs in the Identity than Test condition, but slower RTs for the Unrelated condition, while the Mandarin Chinese L2 group, showed the inverse effect, with the Unrelated condition yielding the fastest RTs, followed by Test, and the slowest RTs in the Identity condition.

As can be seen in Figure 4, the reaction times for the non-native speakers patterned similarly. The RT data, likewise, showed no significant difference between conditions for either L2 group. The additional RT ANOVA that was performed on the non-native participant groups also failed to reach significance.

Table 16. Results from the post-hoc tests for Experiment 4

	English L1	Spanish L2	Mandarin Chinese L2
Test – Identity	t = -0.32	t = 1.16	t = 1.00
Test – Unrelated	t = -3.01*	t = -0.67	t = -0.18
Identity – Unrelated	t = -3.33*	t = 0.49	t = 0.82

3.5 EXPERIMENT 5 – DERIVATIONAL PREFIX *RE-*

With this Experiment, we sought to find if the prefix *re-* demonstrated priming effects on the bare stem of verbs that can take this prefix. The critical items for this experiment, along with their CELEX database frequencies, can be found in Table 25.

The non-parametric test for the error data revealed no significance of Condition for any Group. The mean error rates, which are shown in Table 16, show that the native speakers tested in this experiment logged more accurate answers for the lexical decision tests in this experiment.

The overall error rate was lower in Experiment 5 than any of the other experiments. A total 3% of participant answers were erroneous, and the critical items that were answered incorrectly were not included in the ANOVAs for the reaction time data.

The reaction time ANOVA revealed an effect of Group ($F_1(2, 70) = 4.66$, $p = 0.013$; $F_2(2, 180) = 26.7$, $p < 0.001$) and Condition ($F_1(2, 142) = 11.67$, $p < 0.001$; $F_2(2, 180) = 12.7$, $p < 0.001$) but no effect of the interaction of Group and Condition ($F_1(4, 140) = 0.28$, $p = 0.891$; $F_2(4, 180) = 0.178$, $p = 0.95$). The Group effect may be attributed to the overall faster RTs for the native English speakers and the Condition effect may be the result of the faster reaction times for the Identity primes for all three groups, which can be seen in Table 16.

The reaction times for Conditions 1-3 follow the same pattern in all three groups, although the L2 groups have RTs that are slower than the native English speakers. As opposed to the RT results in this study's Experiments 1-3, the Spanish L2 group seems more similar to the Mandarin Chinese L2 group for derivational prefixes in this experiment. The post-hoc tests for Experiment 5, the results of which can be seen in Table 17, revealed a repetition priming effect for the English L1 and Mandarin Chinese L2 groups, since both groups showed a significant

Table 17. Mean reaction times (in milliseconds) and percent error for Experiment 5

		Mean	Standard Deviation	Percent Error
English L1				
(n = 25)	Identity	521	(80)	1.1%
	Test	569	(79)	1.7%
	Unrelated	586	(105)	2.9%
Spanish L2				
(n = 24)	Identity	643	(190)	7.9%
	Test	685	(215)	3.0%
	Unrelated	686	(215)	7.1%
Mandarin Chinese L2				
(n = 25)	Identity	625	(168)	2.8%
	Test	684	(176)	5.0%
	Unrelated	692	(180)	2.8%

difference between the Identity and Unrelated conditions. Apart from the repetition priming effects, there was no priming effect shown for any of the Groups in this experiment. The additional ANOVA on the non-native speakers showed no significant difference between the two groups.

Table 18. Results from the post-hoc tests for Experiment 5

	English L1	Spanish L2	Mandarin Chinese L2
Test – Identity	t = -2.53*	t = -1.62	t = -2.66*
Test – Unrelated	t = -0.68	t = -0.16	t = -0.30
Identity – Unrelated	t = -3.21*	t = -1.78	t = -2.96*

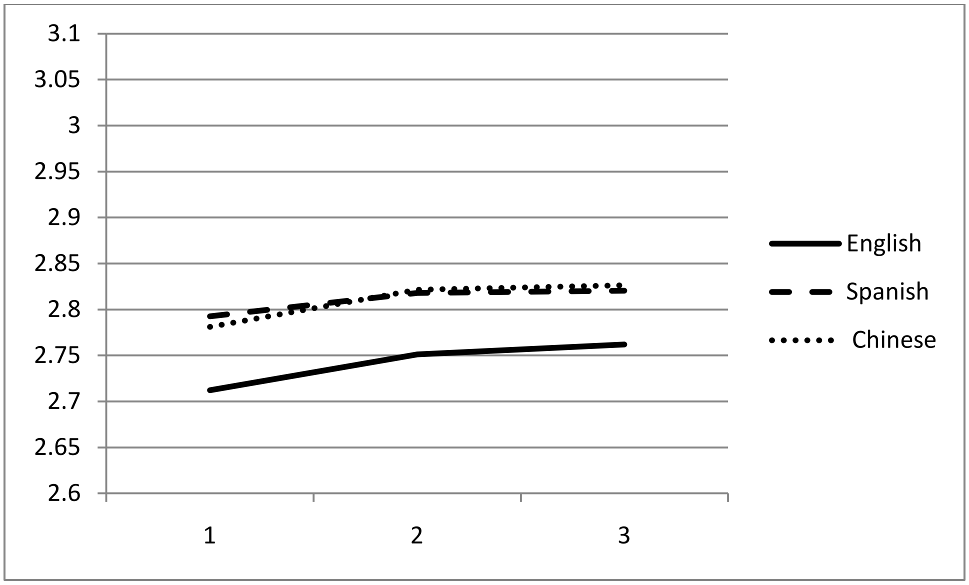

Figure 5. Plot of mean RTs across Conditions for Groups in Experiment 5

4.0 DISCUSSION

4.1 SUMMARY OF RESULTS

The results from our study differ from Silva & Clahsen's (2008) in terms of the inflectional suffix -*ed* and derivational suffix -*ity*. As can be seen in Table 19, the L2 participants in Silva &

Table 19. Summary of priming effects from Silva & Clahsen (2008)

	English L1	German L2	Mandarin Chinese L2	Japanese L2
Experiment 1 – Inflectional suffix -*ed*	full priming	no priming	no priming	
Experiment 2 – Inflectional suffix -*ed*	full priming			no priming
Experiment 3 – Derivational suffix -*ness*	full priming	partial priming	partial priming	
Experiment 4 – Derivational suffix -*ity*	full priming	partial priming	partial priming	

Clahsen (2008) showed no priming effects for the inflectional suffix *-ed*. Table 20, however, shows a full priming effect for the Spanish L2 group in this study for the regular past tense inflectional English affix. The English L1 control group in this study did not exhibit any priming effects for the inflectional suffix *-ed*. As can be seen in Table 9, the mean reaction times for both the English L1 and Spanish L2 groups are faster for the Test condition than the Identity condition. The fact that the native English speakers gave faster reaction times for the Test condition than the Identity condition may have contributed to the lack of priming for the native English speakers in Experiment 1, especially since the Test and Identity RTs are similar and the English L1 post-hoc data also show a significant difference between the Test and Unrelated conditions.

Table 20. Summary of priming effects for Experiments 1 - 5

	English L1	Spanish L2	Mandarin Chinese L2
Experiment 1 – Inflectional suffix *-ed*	no priming	full priming	repetition priming
Experiment 2 – Derivational suffix *-ness*	full priming	no priming	repetition priming
Experiment 3 – Derivational suffix *-ity*	repetition priming	no priming*	no priming
Experiment 4 – Derivational prefix *un-*	full priming	no priming	no priming
Experiment 5 – Derivational prefix *re-*	repetition priming	no priming	repetition priming

**Note: 2nd ANOVA between 2 L2 groups yielded significance, which suggests L1 transfer*

Unlike the full priming effect witnessed for the inflectional suffix -*ity*, the L2 participants did not yield any priming effects for the derivational affixes tested. The English L1 group showed priming effects for the derivational suffix -*ness*, and the derivational prefix *un*-. The lack of full priming for the native speakers in Experiment 3, however, may have been caused by the high error rate found for items in the Unrelated condition. The English L1 group provided reaction times for the Test condition that were faster than the Identity condition. Since erroneous answers are not included in the RT analyses, the larger amount of RTs missing from the Unrelated condition in Experiment 3 may have also influenced the lack of full priming for -*ity*.

4.1.1 Group 1 – English L1

Figure 6 shows the performance of the English L1 control group for these experiments. The mean RTs for Experiments 1 - 4 have a similar pattern, with the fastest RTs occurring for Condition 2, followed by the response times for Condition 1, and Condition 3 having the slowest RTs. In fact, the RTs for the native English speakers were the slowest for Condition 3 all of the Experiments in this study. In Figure 6, we can also observe that the mean RTs exhibit a trend in Experiment 5 that is different than in Experiments 1-4, which corresponds to the lack of priming effect in Experiment 5.

4.1.1.1 Comparison with Silva & Clahsen's (2008) English L1 results

The results for the English L1 group in this study are comparable with Silva & Clahsen (2008)'s findings. In fact, the native speaker control groups in both studies logged reactions times for the Identity and Test conditions that were milliseconds apart. For the inflectional morpheme tested in both this study and Silva & Clahsen (2008), the past tense -*ed* marker, the native speakers showed the slowest RTs under the Unrelated condition. The native English speakers tested in Silva & Clahsen (2008) demonstrated a full priming effect for both the shorter onset time of 30 ms and the longer onset time of 60 ms. Although the native speakers in this study did not show a significant difference between the Identity and Unrelated conditions, the RT data pattern similarly to Silva & Clahsen (2008) for native English speakers.

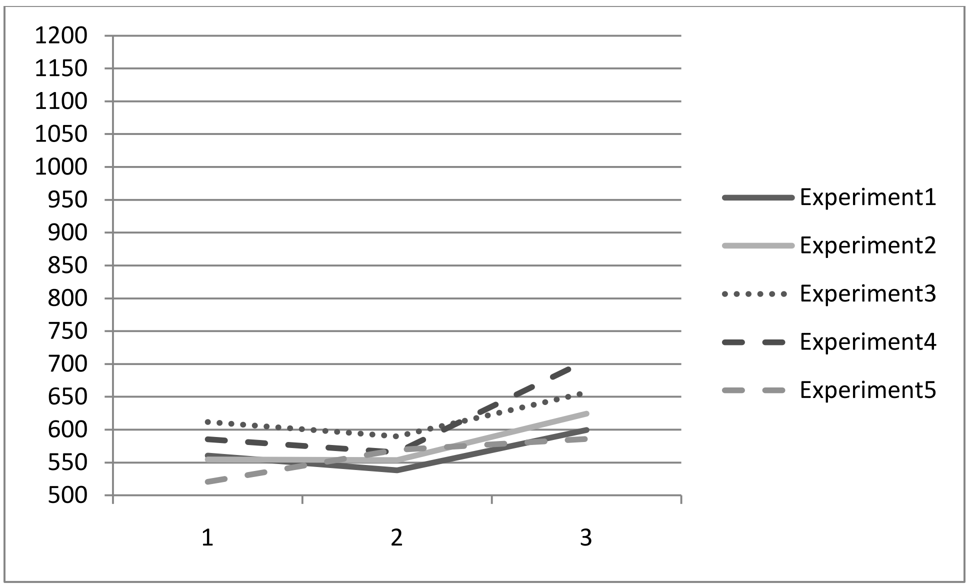

Figure 6. Plots of English L1 mean RTs across Conditions 1 - 3 for Experiments 1 – 5

In addition to the inflectional suffixes, the English L1 participants in Silva & Clahsen (2008) exhibited full priming effects for both derivational suffixes that were tested (-*ness* & -*ity*), which indicates that native speakers of English access the procedural memory system when processing morphologically-complex words in their native language. We witnessed a full priming effect for -*ness* but, not for -*ity* for our English L1 participants. The native English speakers that we tested, however, did demonstrate a repetition priming effect for -*ity*. The lack of a full priming effect for English L1 speakers in our Experiment 3 could be due to the fact that the *-ity* suffix is more opaque which, in turn, contributed to overall slower RTs for this group of participants. As can be seen in Figure 6, the native English speakers gave the slowest RTs for the Identity and Test conditions in Experiment 3.

4.1.2 Group 2 – Spanish L2

The plots of The Spanish L2 group's performance in these experiments can be seen in Figure 7. The pattern of mean RTs for Experiments 4 and 5 is the inverse of the plots for Experiments 1 and 3; however, the pattern of the latter more closely resemble the native speaker participants than the other non-native group. The mean RTs for Experiment 2, on the other hand, are fastest for Condition 3, which indicate the observed lack of priming for the variable *-ity*.

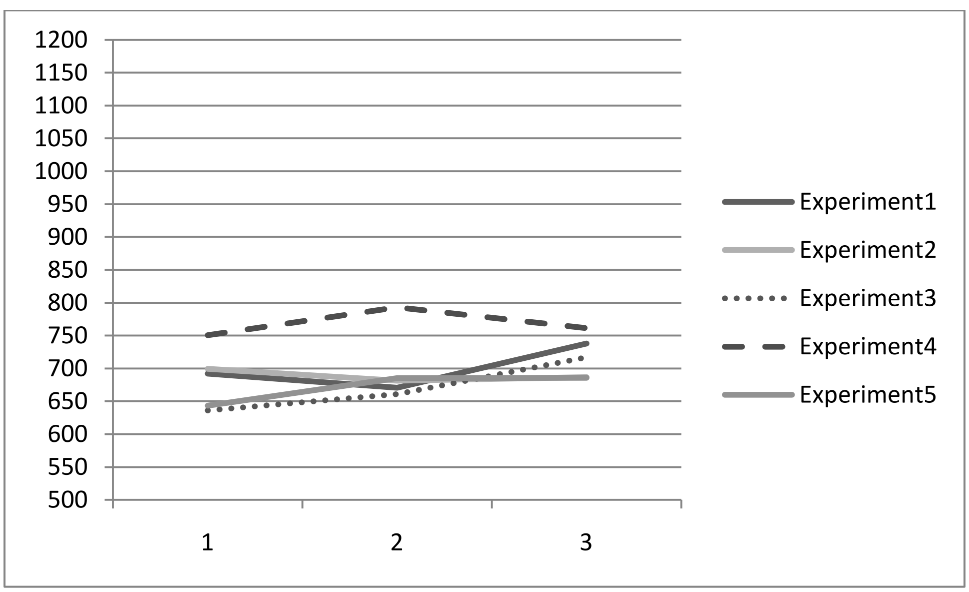

Figure 7. Plots of Spanish L2 mean RTs across Conditions 1 - 3 for Experiments 1 - 5

4.1.3 Group 3 – Mandarin Chinese L2

Participants in The Mandarin Chinese L2 group provided a priming trend that was fairly consistent for all five experiments, which can be seen in Figure 8. The slowest reaction times are found in Condition 2, the Test condition, for all variables tested.

4.1.3.1 Comparison with Silva & Clahsen's (2008) Mandarin Chinese L2 results

The Mandarin Chinese L2 participants of this study produced results that are comparable to those in Silva & Clahsen (2008) for inflectional morphology but dissimilar in terms of derivational morphology. With reference to the simple past tense affix tested in both this study and Silva & Clahsen (2008), our Mandarin Chinese L2 participants yielded RTs for the Test condition that were faster than the Unrelated condition; but the Mandarin Chinese L2 participants in Silva & Clahsen (2008) produced faster RTs in the Unrelated condition than the Test condition. Both groups of Mardarin Chinese L2 speakers showed a repetition priming effect for -*ed*, with the Identity condition being significantly longer than the Unrelated condition. Additionally, neither group of native Mandarin Chinese speakers showed a full priming effect for the inflectional affix -*ed*, which suggests this group of non-native English speakers does not access the procedural memory systsem when processing English verbs with the simple past tense suffix. This lack of morphological processing suggests that native Mandarin Chinese speakers rely on full-form storage for inflected English words.

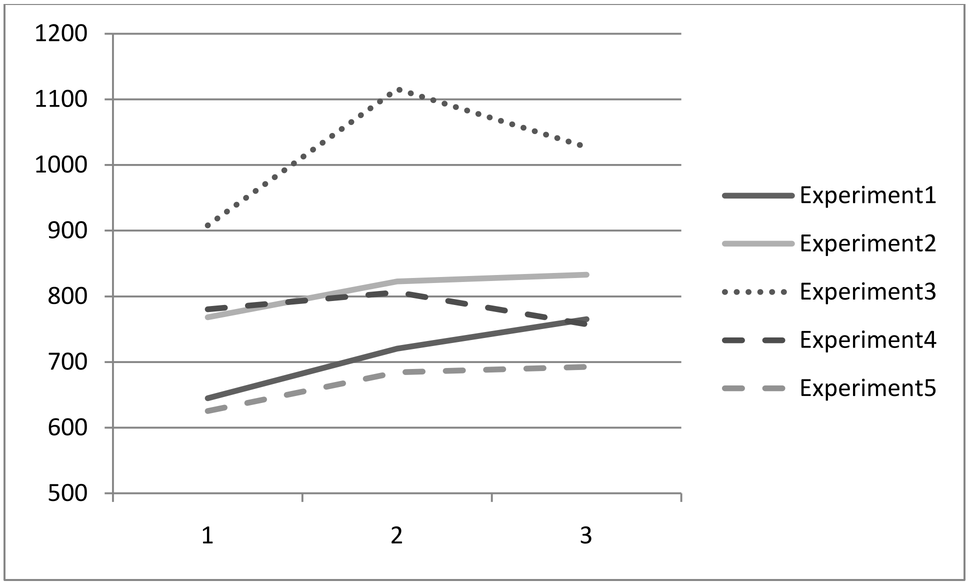

Figure 8. Plots of Mandarin Chinese L2 mean RTs across Conditions 1 - 3 for Experiments 1 - 5

The Mandarin Chinese L2 group in this study also showed a repetition priming effect for the processing of the derivational suffix -*ness*. Although our data do not show any other priming effects for the Mandarin Chinese L2 group in Experiment 2, the non-native speaker results in Silva & Clahsen (2008) show a partial priming effect for -*ness*, as both the German L2 and the Mandarin Chinese L2 groups yielded RTs for both the Identity and Test conditions that were significantly faster than the Unrelated condition.

Silva & Clahsen (2008) also found partial priming effects for the derivational suffix -*ity* in both of the non-native English speaker groups that they tested, whereas the native Mandarin Chinese speakers who participated in this study did not demonstrate any priming effects for this suffix. As can be seen in Figure 8, our Mandarin Chinese L2 participants provided the slowest RTs in Experiment 3, especially for targets paired with morphologically complex primes. Our data suggest that Mandarin Chinese L2 speakers do not access the procedural memory when processing derivational morphology, while Silva & Clahsen (2008) conclude that non-native English speakers have a limited access to the procedural memory.

4.2 IMPLICATIONS TO THE THEORY ON SECOND LANGUAGE PROCESSING

Our intention for replicating Silva & Clahsen (2008) was to test their claims that both native and non-native speakers have access to Ullman's (2001, 2004) declarative/procedural model, but that non-native speakers rely on the declarative memory when processing morphologically complex words. The participants in Silva & Clahsen (2008) yielded priming effects that suggested that morphologically complex words with inflectional morphemes have whole word representations in the mental lexicon and ones that contain derivational suffixes may be processed within the mental grammar. These results attempt to account for differences in the rate of native and non-native language processing.

4.2.1 Processing of inflectional suffixes

The priming results provided by the Mandarin Chinese L2 group in these experiments are, more or less, similar to the results provided by the Mandarin Chinese L2 participants in Silva & Clahsen (2008). Overall, this group of non-native speakers provided slower RTs and higher error rates than the other non-native English speakers tested in both studies. The mean scores for both L2 groups on both proficiency measures used in this study were not significantly different, suggesting that both L2 groups in this study would be able to perform at the same level. Of the two L2 groups tested in this study, however, the Spanish L2 group was slightly more proficient than the Mandarin Chinese L2 group, which can be seen in the trend effect for both proficiency measures (the MTELP and the cloze test). The priming effects that we recorded in this study for the Mandarin Chinese L2 group could show that native speakers of Mandarin Chinese have a greater difficulty processing morphologically complex words than native Spanish speakers.

The results from the Spanish L2 participants provide results that are divergent to those found for non-native speakers in Silva & Clahsen (2008) and Neubauer & Clahsen (2009). First of all, the Spanish group showed a full priming effect for the inflectional suffix -*ity*. These results could be the result of L1 transfer, although not overly so, as the past tense in Spanish is not formed through the same affixation process as it is in English. The extent to which Spanish L2 speakers are transferring knowledge from their native language or processing the morphologically complex words using the the mental grammar is unclear. However, the full priming results witnessed for the Spanish L2 group in Experiment 1 suggest that L2 learners are able to process regularly inflected English verbs.

Comparing the results for the Spanish L2 group across experiments, the full priming results from Experiment 1, which tested the inflectional suffix -*ed*, suggest that native Spanish speakers are processing English inflectional morphology differently than derived word forms. This data contradicts the claim made in Silva & Clahsen (2008) that “L2 learners appear to make use of morphologically structured representations for derived (but not for inflected) word forms during processing” (p. 256). This difference in priming results for the Spanish L2 participants could be explained by the inherent difference between inflectional and derivational morphology (Matthews, 1991).

Chomsky (1995) believes that derivational morphology is part of the mental lexicon; whereas inflectional morphology is formed by a process "involving computational operations of a broader syntactic scope" (p. 20). Inflectional rules, including number, tense, person, be added to the bare stem of a word during on-line processing of complex words containing inflectional affixes; but derivational rules, like words with irregular inflection, would be part of the system that may be stored in the mental lexicon, depending on the type of derivational affix (i.e., whether the affix is productive or not) and the morphological process that is used to create the complex word.

The length of exposure time for L2 learners could have also been a contributing factor in the full priming effects witnessed for the Spanish L2 group in Experiment 1. Compared with the Mandarin Chinese L2 group, the Spanish L2 group had been exposed to English at an earlier age, as 7 of the 24 qualified participants in the Spanish L2 group received English instruction before the age of 10, however, that instruction was in an EFL classroom setting and only for a few hours per week. It is possible that the results from the Spanish L2 participants for Experiment 1 support the claim made by Ullman (2001) that a longer amount of practice with a second language can lead to a more automatic processing of grammatical structures. This would pose problems to the dual-mechanism models (Pinker, 1994; Chomsky, 1995) that propose an innate set of grammar rules, unless L2 learners are transferring grammatical rules from their L1 when processing words in their L2.

4.2.2 Processing of derivational suffixes

As with inflectional morphology, our results for the Mandarin Chinese L2 group were similar to those found by Silva & Clahsen (2008), although we did not find partial priming effects for derivational suffixes. Additionally, our Spanish L2 group showed no priming effects for any derivational affixes. We did find, however, a possible instance of L1 transfer in the Spanish L2 group's processing of the derivational suffix -*ity*. Although the Spanish L2 participants did not show priming effects in our Experiment 3, which tested the influence of the derivational affix -*ity*, we did find a significant difference between the L2 groups. The native Spanish speakers also provided mean reaction times that patterned more like the native English speakers than the Mandarin Chinese L2 group for this experiment, which suggests that the Spanish L2 speakers were transferring morphological processing from their native language while processing the English primes tested in Experiment 3. This potential instance of L1 transfer conflicts with results found in Silva & Clahsen (2008) and Neubauer & Clahsen (2009) which claim that non-native processing of morphologically complex English words is consistent, regardless of the L1.

4.2.3 Processing of derivational prefixes

The results of these experiments suggest that non-native speakers do not process derivational prefixes using the procedural memory system. Native speakers, on the other hand, exhibit full or no priming effects, depending on derivational prefix. L1 participants successfully decomposed complex words that are derived from the prefix *un*- into a bare stem and its morphological parts, which implies processing. The semantic meaning in *un*- is consistent when applied to the verbs tested in this study as well as other word categories, e.g., adjectives (*unhappy*) or adverbs (*unfortunately*), which might explain why native speakers yielded priming effects for this variable in Experiment 4. The non-native speaker results, however, support the theory that non-native speakers rely more on declarative memory when processing words in their second language. This finding is consistent with production data reported in Friedline & Juffs (submitted).

The results from this Experiment 4, which tests the derivational prefix *un*-, suggest that native speakers store *un*- as a morphological unit when processing verbs that are formed with this prefix. Non-native speakers, however, did not exhibit any priming effects. The faster RTs in the Mandarin L2 group under the Unrelated condition, in particular, suggest that the non-native speakers are not benefitting from any kind of priming. The slower RTs for the Test condition might also be attributed to the lower frequency of the primes used in this condition, especially in comparison with the frequency of the bare-stemmed verbs in the Identity condition.

The priming results for the derivational prefix *un*- differ from the results for *re*-. Both native and non-native speaker groups yielded no priming effects for *re*-. The variable tested in our Experiment 5 yielded no priming effects, which suggests that even native speakers fail to process the words formed with the derivational prefix *re*-. The lack of morphological decomposition witnessed in this experiment could be the result of the orthographic representation of the tested prefix (Marslen-Wilson, Komisarjevsky, Waksler, & Older, 1994). In a sight recognition task, such as the lexical decision tasks in this study, the presentation of the prefix *re*- in a prime, like *rebuild*, might prevent participants from accessing the morphological structure of these primes. The reason for this is that the prefix *re*- contains the exact same orthographic structure and positioning at the beginning of the word as countless other words in the English lexicon. The difference between a prefixed word, like *rebuild*, and words like *remiss* or *return*, is that the "to do again" meaning of the prefix is only found in *return*. Compare also, English words that are prefixed with *re-* and that have an complete form overlap with a entirely different English word, such as: *realign-real* or *reapply-reap*.

Similarly, we did not find priming effects for the Spanish L2 group in Experiment 5, even though Spanish uses the same derivational suffix as English to indicate the meaning "to do again." The results for the Spanish L2 participants are difficult to interpret because the observed lack of priming could be caused by not only the effect of orthography (that might also have inhibited processing in the English L1 participants), but also the fact that non-native speakers store prefixed English words in the mental lexicon.

The processing of the prefix might be inhibited because of the nature of the task performed. The morphological structure of the prefix *re-* is not as readily available in visual tasks as auditory tasks, as the *re-* in *rebuild* is pronounced differently than in *remiss* and *return*, which could have caused an inhibitory effect for the participants in this study. The orthographic structure of a morpheme might inhibit processing of the complex word by the procedural memory system. Rastle, Davis, and New (2004), also, found that a combination of letters that resembled morphological units did not provide priming results unless the primes had a "morpheme-like" relationship to the stem. This possible facilitory effect for the prefix *re-* would have to be tested in order to determine if the orthographic representation is inhibiting priming or whether all complex words prefixed with *re-* receive whole-word representations in the mental lexicon.

4.3 EVALUATION OF RESEARCH QUESTIONS

The results from the masked priming experiments in this study show different priming patterns for the native participants and the non-native participants. The Spanish L2 group, in particular, provided results that differ from the L2 participants in Silva & Clahsen (2008) because they demonstrated processing for inflectional morphology as well as possible L1 transfer for a derivational suffix that has an equivalent meaning, but not shape, in their native language (Hagiwara, Sugioka, Ito, Kawamura, & Shiota, 1999). The Spanish L2 group also logged mean reaction times that pattern more like the English L1 than the Mandarin Chinese L2 group.

Secondly, our study also suggests that non-native speakers do not decompose morphologically complex words by accessing the procedural memory system, if the word is formed by the addition of a derivational prefix. Native English speakers are able to use the procedural memory system to process derivational prefixes, although this is possible only in instances where the orthography of the morpheme is unambiguous (which is problematic in the case of *re-*) and the meaning of the affix is consistent across word forms (which we see in the case of *un-*).

Our findings, also, cannot claim that L1 is not a factor in the difference between native and non-native word processing. The potential L1 transfer that we witnessed in the Spanish L2 data from Experiment 3, that tested the influence of the derivational prefix -*ity*, suggest that non-native speaker may have access morphological information from their first language while processing their second. They can, therefore, use this guidance to create morphologically complex/rule-based representations in their L2 grammar.

Finally, even though Spanish and English use the same morphological prefix to indicate the same meaning, the Spanish L2 group did not show priming effects that differed from the Mandarin Chinese L2 group. However, the English L1 control group also failed to exhibit morphological processing effects for the processing of verbs prefixed by *re-*. This lack of priming might have been a consequence of orthographic representation of the primes in the visual word recognition tasks used in these experiments. In such cases, we suggest that non-native and native processing are indistinguishable.

5.0 CONCLUSIONS

We found that native and non-native speakers do not always process morphologically complex English words differently. Native English speakers tend to access procedural memory when processing the inflectional past tense *-ed* marker, derivational suffixes and the derivational prefix *un-*. The Mandarin Chinese L2 group relies more on the declarative memory to process morphologically complex words; but Spanish L2 speakers, however, demonstrated full priming effects for the inflectional *-ed* suffix, which suggests that non-native speakers can process inflectional morphology in a way similar to native speakers.

The difference in native and non-native processing suggests that non-native speakers are indeed more prone to store morphologically complex words in the declarative memory system, but are not always limited to this. This latter caveat is necessary because this study witnessed a possible instance of L1 transfer in the Spanish L2 participants' processing of the derivational suffix, *-ity*, which was not observed in the German L2, Mandarin Chinese L2, Japanese L2 results in Silva & Clahsen (2008).

5.1 LIMITATIONS OF THIS STUDY

Silva & Clahsen (2008) controlled for stem length and frequency for the primes in Experiments 1 - 3. However, the primes used to test the effects of derivational prefixes had a variety of frequency rates. We attempted to prevent frequency effects in Experiments 4 and 5 by pairing targets with Unrelated primes with similar frequencies.

An additional difference in experiment design between this study and Silva & Clahsen (2008) is that the L2 participants in Silva & Clahsen (2008) took a multiple-choice test to demonstrate knowledge that the critical items tested were words in the English language. We neglected to include this controlling measure in our experiments. Since we needed to test for proficiency and our study tested 105 critical items, the inclusion of this extra measure would have greatly increased the total testing time for the non-native participants and potentially affected participant performance.

5.2 FUTURE RESEARCH

Studies that focus on non-native processing of derivational morphology are not abundant in the psycholinguistic literature, so additional on-line studies that measure non-native morphological processing are needed in order for us to gain a better understanding how second language learners process their L2. Based on the results of the Spanish L2 participants in these experiments, the most obvious recommendation that can be made for future research would be to test for priming effects for derivational affixes in Spanish on English L2 learners. Also, studies that examine the nature of non-native word processing in languages with more overt orthographic representations for morphological structures and/or transparent relationships between complex words and their stems might provide additional data to address this question.

Finally, the Mandarin Chinese L2 participants in this study reported having difficulty reading the targets in the lexical decision tasks, due to the fact that the targets were shown in uppercase letters. In order to measure the extent of influence that the script had on the Mandarin Chinese L2 participants in this study, it would be necessary to administer lexical decision tasks in which the targets are presented in lowercase letters.

APPENDIX

LISTS OF CRITICAL ITEMS

A.1 EXPERIMENT 1

Table 21. Variables for Experiment 1

Test	Target	Unrelated
boiled	boil	jump
cured	cure	watch
dragged	drag	bump
faded	fade	pinch
folded	fold	wink
freed	free	climb
heated	heat	bank
hired	hire	drill
kicked	kick	cloth
lacked	lack	type
linked	link	wash
locked	lock	track

A.1 (CONTINUED)

Test	Target	Unrelated
melted	melt	guide
packed	pack	itch
posed	pose	wave
prayed	pray	bake
rested	rest	shave
soaked	soak	pace
warned	warn	block
wiped	wipe	fish
wrapped	wrap	greet

A.2 EXPERIMENT 2

Table 22. Variables for Experiment 2

Test	Target	Unrelated
bareness	bare	happy
boldness	bold	rough
coolness	cool	poor
dampness	damp	fair
dullness	dull	heavy
dumbness	dumb	short
firmness	firm	pretty
flatness	flat	rich
fondness	fond	hard
limpness	limp	bitter
loudness	loud	fit
meanness	mean	quick
mildness	mild	black
nearness	near	dizzy
neatness	neat	dark
paleness	pale	vague
ripeness	ripe	strict
rudeness	rude	bright
soreness	sore	mad
weakness	weak	numb

A.3 EXPERIMENT 3

Table 23. Variables for Experiment 3

Test	Target	Unrelated
acidity	acid	small
aridity	arid	dark
brutality	brutal	fresh
divinity	divine	narrow
docility	docile	fake
fatality	fatal	little
fertility	fertile	strange
hostility	hostile	smooth
humidity	humid	loud
liquidity	liquid	pale
maturity	mature	coarse
mobility	mobile	tired
neutrality	neutral	long
obscurity	obscure	stubborn
profanity	profane	clean
rigidity	rigid	quiet
solemnity	solemn	fine
sterility	sterile	great
toxicity	toxic	direct
validity	valid	rough
virginity	virgin	straight

A.4 EXPERIMENT 4

Table 24. Variables used in Experiment 4 with CELEX frequencies

Target	Target frequency	Prime	Prime frequency	Unrelated	Unrelated frequency
bend	1179	unbend	6	dance	1177
cork	98	uncork	7	rinse	147
curl	278	uncurl	x	pluck	151
do	80717	undo	172	say	76541
dress	1562	undress	149	jump	1195
hinge	63	unhinge	12	fret	89
hook	670	unhook	23	search	810
knot	251	unknot	x	cheat	250
load	556	unload	122	knit	169
mask	354	unmask	24	squat	219
pick	3386	unpick	8	laugh	3058
quote	728	unquote	7	kick	753
ravel	33	unravel	61	dent	34
reel	96	unreel	x	strew	103
roll	1287	unroll	49	fear	1410
screw	187	unscrew	44	pluck	151
seat	1944	unseat	11	plan	2416
snap	61	unsnap	x	jog	82
tangle	155	untangle	15	bark	181
tie	1100	untie	x	mix	910
wind	293	unwind	30	cough	223
zip	32	unzip	39	prance	40

A.5 EXPERIMENT 5

Table 25. Variables used in Experiment 5 with CELEX frequencies

Target	Target frequency	Prime	Prime frequency	Unrelated	Unrelated frequency
build	4336	rebuild	256	hope	4080
claim	1794	reclaim	85	deal	1871
coil	91	recoil	39	fret	89
fill	2461	refill	74	drop	2251
fit	373	refit	13	bite	492
fuel	1074	refuel	37	warn	883
gain	1567	regain	237	clean	1123
join	2594	rejoin	68	smile	2894
load	556	reload	20	grasp	451
make	41842	remake	29	give	22912
marry	2245	remarry	41	drink	2321
paint	1285	repaint	30	deal	1871
pay	6268	repay	141	send	4822
play	7245	replay	58	hold	8324
print	481	reprint	25	kneel	406
state	5794	restate	29	lose	6086
stock	23	restock	12	waltz	26
take	34323	retake	4	see	36958
tell	19040	retell	13	put	14426
use	2216	reuse	15	touch	1967

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